1

Solid State

DPP 1.1

Classification of Solids, Crystalline Solids, Crystal Lattice, Unit Cell and Crystal System

Subjective Type

1. Comment on the statement "Quartz is crystalline SiO_2 whereas silica glass is amorphous SiO_2".
2. Under which situations can an amorphous substance change to crystalline form?
3. What are polymorphs compounds? Give an example.
4. The internal arrangement of atoms is regular in crystalline solids yet they are anisotropic in nature. Why?
5. (i) Why uncharged atoms or molecules never crystallize in simple cubic structures?
   (ii) Why an end-centred unit cell cannot be cubic? What is the highest possible symmetry for this type of unit cell?

Single Correct Answer Type

6. A crystal may have one or more planes and one or more axes of symmetry but it possesses:
   (a) two centres of symmetry
   (b) one centre of symmetry
   (c) no centre of symmetry
   (d) none of the above
7. TiO_2 is well known example of:
   (a) triclinic system (b) tetragonal system
   (c) monoclinic system (d) none of these
8. A compound contains two types of atoms X and Y. Its crystal structure is a cubic lattice with X atoms at the corner of the unit cells and Y atoms at the body centres. The simplest formula is
   (a) X_2Y (b) XY (c) XY_2 (d) XY_3
9. The crystal system of a compound with unit cell dimensions $a = 0.387$, $b = 0.387$ m and $c = 0.504$ nm and $\alpha = \beta = 90^\circ$ and $= 120^\circ$ is:
   (a) cubic (b) hexagonal
   (c) orthorhombic (d) rhombohedral
10. The crystals are bounded by plane faces (f), straight edges (e) and interfacial angle (c). The relationship between these is:
    (a) $f + c = e + 2$ (b) $f + e = c + 2$
    (c) $c + e = f + 2$ (d) none of these
11. A crystal is a repetition of a pattern called
    (a) motif (b) basis
    (c) both (a) and (b) (d) none of these
12. The sharp melting point of crystalline solids is due to ________.
    (a) a regular arrangement of constituent particles observed over a short distance in the crystal lattice
    (b) a regular arrangement of constituent particles observed over a long distance in the crystal lattice
    (c) same arrangement of constituent particles in different directions
    (d) different arrangement of constituent particles in different directions
13. Graphite cannot be classified as ________.
    (a) conducting solid (b) network solid
    (c) covalent solid (d) ionic solid

Multiple Correct Answers Type

14. Amorphous solids can also be called ________.
(a) pseudo solids (b) true solids
(c) super cooled liquids (d) super cooled solids

15. Crystalline solids have:
(a) sharp melting point
(b) anisotropic character
(c) the character of supercooled liquid
(d) smooth cooling curve

16. If the three interaxial angles defining the unit cell are all equal in magnitude, the crystal cannot belong to the
(a) Orthorhombic system (b) Cubic system
(c) Hexagonal system (d) Triclinic system

17. Crystal systems in which no two axial lengths are equal are
(a) Tetragonal (b) Orthorhombic
(c) Monoclinic (d) Triclinic

18. With respect to graphite and diamond, which of the following statement(s) given below is(are) correct?
(a) Graphite is harder than diamond
(b) Graphite has higher electrical conductivity than diamond
(c) Graphite has higher thermal conductivity than diamond
(d) Graphite has higher C–C bond order than diamond.

Matching Column Type

19. Match the type of unit cell given in Column I with the features given in Column II.

Column I	Column II
A. Primitive cubic unit cell	1. Each of the three perpendicular edges compulsorily have the different edge length i.e., $a \neq b \neq c$.
B. Body centred cubic unit cell	2. Number of atoms per unit cell is one
C. Face centred cubic unit cell	3. Each of the three perpendicular edges compulsorily have the same edge length i.e., $a = b = c$.
D. End centred orthorhombic unit cell	4. In addition to the contribution from the corner atoms, the number of atoms present in a unit cell is one.
	5. In addition to the contribution from the corner atoms, the number of atoms present in a unit cell is three.

Integer Type

20. Calculate the number of atoms in a cubic based unit cell having one atom on each corner and two atoms on each body diagonal.

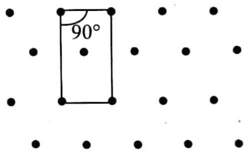
21. Sodium crystallizes in a bcc unit cell. The approximate number of unit cells in 9.2 g of sodium (Atomic mass of Na = 23) are of the form $y \times 10^x$. What is y?

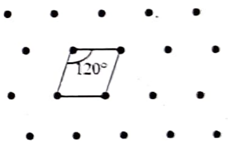
Comprehension Type

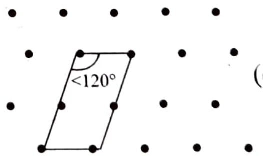
Ice is water, frozen into a solid state. Ice molecules can exhibit up to sixteen different phases that depend on temperature and pressure. As a naturally-occurring crystalline inorganic solid with an ordered structure, ice is considered a mineral. An unusual property of ice frozen at atmospheric pressure is that the solid is approximately 83% less dense than liquid water.

Answer the following questions:

22. Which of the following diagram represents the location of lattice points within the space lattice?

(a)


(b)


(c)


(d) None of these

23. Liquid H_2O is densest, essentially 1.00 g/cm^3, at 4°C and becomes less dense as the water molecules begin to form crystals ice as the freezing point is reached.
(a) Rhombohedral (b) Hexagonal
(c) Orthorhombic (d) Cubic

Answers Key

Single Correct Answer Type

6. (b) **7.** (b) **8.** (b) **9.** (b) **10.** (a)
11. (c) **12.** (b) **13.** (d)

Multiple Correct Answers Type

14. (a, c) **15.** (a, b) **16.** (c, d) **17.** (b, c, d)
18. (b, d)

Matching Column Type

19. (A → 2, 3), (B → 3, 4), (C → 3, 5), (D → 1, 4)

Integer Type

20. (9) **21.** (1)

Comprehension Type

22. (b) **23.** (b)

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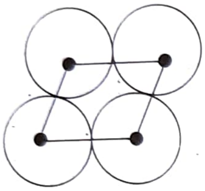
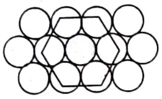
DPP 1.2

scc, fcc, bcc, Nearest Neighbouring Distance, Next-Nearest Neighbouring Distance, Packing Fraction

Subjective Type

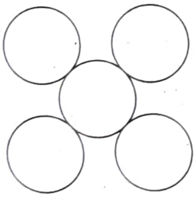
1. (i) What is the relation between the radius of circle and the length of parallelogram for the unit cell shown in figure below?





(ii) How many nearest neighbour circles does a given circle have in the second figure above?

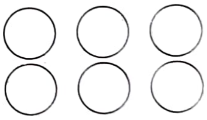
2. What is the packing efficiency of the two-dimensional square unit cell shown below?

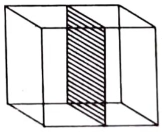


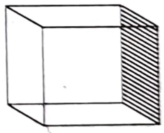
3. Xenon crystallises in the face-centred cubic lattice and the edge of the unit cell is 620 pm. What is the nearest neighbour distance and what is the radius of Xenon atom?
4. Calculate the approximate number of unit cells present in 1 g of gold. Given that gold crystallizes in the face-centred cubic lattice. (Atomic mass of gold = 197 u).

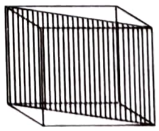
Single Correct Answer Type

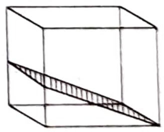
5. The intermetallic compound LiAg has a cubic crystalline structure in which each Li atom has 8 nearest neighbour silver atoms and vice-versa. What is the type of unit cell?
   (a) Body centred cubic
   (b) Face centred cubic
   (c) Simple cubic for either Li atoms alonge or Ag atoms alone
   (d) None of the above
6. A compound alloy of gold and Cu crystallizes in a cubic lattice in which the gold atoms occupy the lattice points at the corners of a cube and the copper atoms occupy the centres of each of the cube faces. What is the empirical formula of this compound?
   (a) $AuCu_3$ (b) Au_3Cu
   (c) Au_2Cu_3 (d) AuCu
7. How many 'nearest' and 'next nearest' neighbours respectively potassium have in bcc lattice?
   (a) 8, 8 (b) 8, 6 (c) 6, 8 (d) 8, 2
8. The ratio of packing density in fcc, bcc and cubic structure is respectively:
   (a) 1 : 0.92 : 0.70 (b) 0.70 : 0.92 : 1
   (c) 1 : 0.70 : 0.92 (d) 0.92 : 0.70 : 1
9. Sodium metal crystallizes in a body centred cubic lattice with the cell $a = 4.29$ Å. The radius of sodium atom is:
   (a) 1.8574 (b) 2.8574
   (c) 3.8574 (d) none of these
10. Which of the following shaded plane in fcc lattice contains arrangement of atoms as shown below:



(a) 

(b) 

(c) 

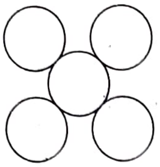
(d) 

11. A metal crystallises in bcc lattice. The % fraction of edge length not covered by atom is:
    (a) 10.24% (b) 13.4% (c) 12.4% (d) 11.4%

Multiple Correct Answers Type

12. Given is the arrangement of atoms in a crystallographic plane. Which plane correctly represent(s) the drawn structure?
    (a) Face plane in fcc
    (b) Body diagonal plane in fcc

(c) Face plane in bcc
(d) Body diagonal plane in bcc



13. Potassium crystallizes in a body-centred cubic lattice. Then
(a) The distance between nearest neighbors is 4.50 Å
(b) The distance between next-nearest neighbors is 5.20 Å
(c) Each K have nearest neighbors equal to 4.
(d) Each K have nearest neighbors equal to 6.

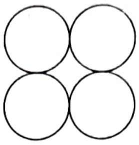
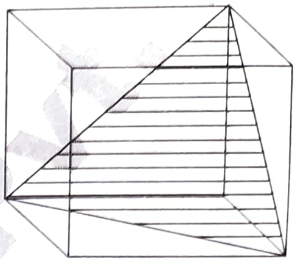
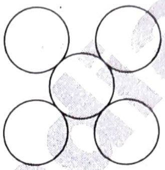
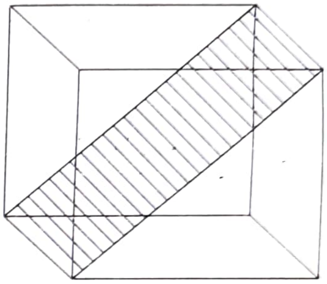
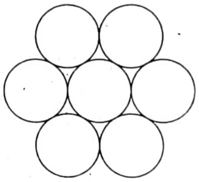
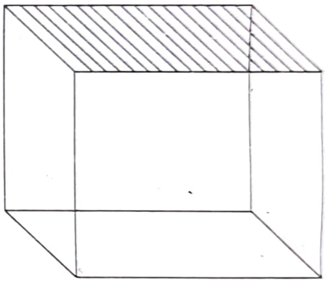
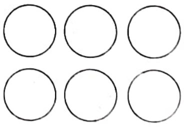
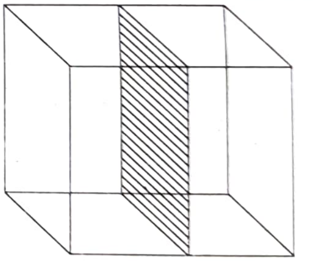
14. Which of the following is/are correct for the unit cell of element?
(a) For simple cubic lattice, $a = \frac{r}{2}$
(b) For body centred cubic lattice, $a = \frac{\sqrt{3}r}{4}$
(c) For face centred cubic lattice, $a = 2\sqrt{2}\,r$
(d) $d = \frac{ZM \times 10^{30}}{a^3 N_0}$ gcm^{-3}, where a is in pm

15. Which statements are correct?
(a) Atoms on a body diagonal are inside the cube and are shared by adjacent atoms.
(b) Atoms on a face diagonal are shared by two unit cells and only 1/2 of each atom belongs to each unit cell.
(c) Atoms on a body diagonal are inside the cube and are not shared by any adjacent atoms.
(d) Total number of atoms in a unit cell $= \frac{n_c}{8} + \frac{n_f}{1} + \frac{n_b}{2} + \frac{n_e}{4}$
where n_c, n_f, n_b and n_c are no. of atoms at the corner, face centre, body centre and edge centre of a unit cell resp.

16. If all the atoms are removed from a single axis passing through the centre of the cube then choose the incorrect option. If x are at the corner of cube and y atoms are at face-centre, then
(a) $Zeff_{(x)} = 1$
$Zeff_{(y)} = 3$
Formula $= xy_3$
(b) $Zeff_{(x)} = 3$
$Zeff_{(y)} = 1$
Formula $= x_3y$
(c) $Zeff_{(x)} = 8$
$Zeff_{(y)} = 1$
Formula $= x_8y$
(d) $Zeff_{(x)} = 1$
$Zeff_{(y)} = 8$
Formula $= xy_8$

Matching Column Type

17. Match Column I with Column II:

Column I (Arrangement of the atoms or constituent ions)	Column II (Planes in fcc arrangement)
(a) 	(p) 
(b) 	(q) 
(c) 	(r) 
(d) 	(s) 

Integer Type

18. Consider a cube 1 of Body Centered cubic unit cell of edge length 4 pm. Now atom at the body centre can be viewed to be lying on the corner of another cube 2. Find the volume common to cube 1 and cube 2 in pm^3.

19. If edge length of a bcc crystallized Fe is $8\sqrt{3}$, the atomic radius is ...

Comprehension Type

In crystalline solids, atoms or molecules are arranged in a regular and long range order fashion in a three dimensional pattern. These have sharp melting point, flat faces, sharp edges, bounded by well defined planes. A large number of unit cells, each of which possess a definite geometry bounded by plane faces give rise to the formation of a crystal. A point at the corner of unit cell contributes for 1/8 of each such point to unit cell. A point along an edge contribute for 1/4 of each such point to unit cell. A body centred point contributes for 1 each such points to unit cell. Coordination number is the number of nearest neighbours that each ion is surrounded by an oppositely charged ions. Radius of unit cell in sc, fcc and bcc is $\frac{a}{2}, \frac{a}{2\sqrt{2}}$ and $\frac{\sqrt{3}a}{4}$ where a is edge length of cell.

Answer the following questions:

20. An alloy of Cu and gold crystallizes in cubic lattice in which the gold atoms occupy the lattice points at the corners of cube and copper atoms occupy the centre of each face. The formula of this compound is:

(a) $AuCu_3$ (b) $AuCu$

(c) $AuCu_2$ (d) $CuAu_3$

21. Packing factors for a body centred cubic and simple cubic structure are:

(a) 0.68, 0.524 (b) 0.524, 0.68

(c) 0.48, 0.52 (d) 0.52, 0.48

22. In solid NH_3, each NH_3 molecule has six other NH_3 molecules as nearest neighbours. ΔH of sublimation of NH_3 at the melting point is 30.8 kJ/mol and the estimated ΔH of sublimation in absence of H-bonding is 14.3 kJ/mol. The strength of H-bond in NH_3 ion kJ/mol is:

(a) 5.5 (b) 11.0 (c) 16.5 (d) 2.75

Answers Key

Subjective Type

1. (i) $a = 2R$ (ii) CN = 6 **2.** 78.54%

3. $d = 438.5$ pm, $r = 219.25$ pm **4.** 7.64×10^{20}

Single Correct Answer Type

5. (a) **6.** (a) **7.** (b) **8.** (a) **9.** (a)

10. (c) **11.** (b)

Multiple Correct Answers Type

12. (a, d) **13.** (a, b, d) **14.** (c, d) **15.** (b, c)

16. (b, c, d)

Matching Column Type

17. (a → s), (b → p, q), (c → q, r), (d → r, s)

Integer Type

18. (8) **19.** (6)

Comprehension Type

20. (a) **21.** (a) **22.** (a)

DPP 1.3

CCP, HCP, Octahedral and Tetrahedral Voids

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Subjective Type

1. Titanium crystallizes in a face-centred cubic lattice. It reacts with carbon or hydrogen interstitially, by allowing atoms of these elements to occupy holes in the host lattice. Hydrogen occupies tetrahedral holes, but carbon occupies octahedral holes.
   (a) Predict the formulas of titanium hydride and titanium carbide formed by saturating the titanium lattice with either "foreign" element.
   (b) Account for the fact that hydrogen occupies tetrahedral holes while carbon occupies octahedral holes.
2. A compound forms a hexagonal close-packed structure. What is the total number of voids in 0.5 mol of it? How many of these are tetrahedral voids?
3. A unit cell is obtained by the close packing of layers of atoms in ABAB… pattern. How many tetrahedral and octahedral voids are there in the unit cell?
4. How much empty space is left in hexagonal close packing of spheres in 3-D?
5. What is the arrangement of atoms in the lattice structure of diamond and give contribution of each C atom?

Single Correct Answer Type

6. How many tetrahedral holes are occupied in diamond?
   (a) 25% (b) 50% (c) 75% (d) 100%
7. If R is the radius of the octahedral voids and r is the radius of the atom in close packing, then:
   (a) $\frac{r}{R}=2.41$ (b) $\frac{r}{R}=4.76$
   (c) $\frac{r}{R}=3.22$ (d) $\frac{r}{R}=9.1$
8. Lithium selenide can be described as a closest packed array of selenide ions with lithium ions in all of the tetrahedral holes. Formula of lithium selenide is
   (a) Li_2Se (b) LiSe (c) $LiSe_2$ (d) Li_3Se
9. Total number of voids in 0.5 mole of a compound forming hexagonal closed packed structure are
   (a) 6.022×10^{23} (b) 3.011×10^{23}
   (c) 9.034×10^{23} (d) 4.516×10^{23}
10. In which pair most efficient packing is present?
    (a) hcp and bcc (b) hcp and ccp
    (c) bcc and ccp (d) bcc and simple cubic cell
11. Which of the following statement is not true about the hexagonal close packing?
    (a) The coordination number is 12
    (b) It has 74% packing efficiency
    (c) Tetrahedral voids of the second layer are covered by the spheres of the third layer
    (d) In this arrangement spheres of the fourth layer are exactly aligned with those of the first layer
12. Which of the following statements is wrong?
    (a) ABCABC … Packing gives face centred cubic unit cell
    (b) ABABAB … Packing gives hexagonal unit cell
    (c) ABCABC … Packing has a void fraction of 0.26
    (d) ABABAB … Packing has a void fraction of 0.32

Multiple Correct Answers Type

13. In which of the following arrangements octahedral voids are formed?
    (a) hcp (b) bcc
    (c) simple cubic (d) fcc
14. Which of the following is not true about the voids formed in 3 dimensional hexagonal close packed structure?
    (a) A tetrahedral void is formed when a sphere of the second layer is present above triangular void in the first layer
    (b) All the triangular voids are not covered by the spheres of the second layer
    (c) Tetrahedral voids are formed when the triangular voids in the second layer lie above the triangular voids in the first layer and the triangular shapes of these voids do not overlap
    (d) Octahedral voids are formed when the triangular voids in the second layer exactly overlap with similar voids in the first layer
15. In face centred cubic structure, the octahedral voids are located at:
    (a) edge centres (b) body centre
    (c) face centres (d) corners
16. In which of the following type of solids, the coordination number and packing efficiency are same:
    (a) bcc type solids (b) simple cubic type solid
    (c) hcp type solids (d) fcc type solid
17. The co-ordination number of FCC structure for metals is 12, since

(a) each atom touches 4 others in same layer, 3 in layer above and 3 in layer below
(b) each atom touches 4 others in same layer, 4 in layer above and 4 in layer below
(c) each atom touches 6 others in same layer, 3 in layer above and 3 in layer below
(d) each atom touches 3 others in same layer, 6 in layer above and 6 in layer below

Matching Column Type

18. Match the type of packing given in Column I with the items given in Column II.

Column I	Column II
(a) Square close packing in two dimensions	1. Triangular voids
(b) Hexagonal close packing in two dimensions	2. Pattern of spheres is repeated in every fourth layer
(c) Hexagonal close packing in three dimensions	3. Coordination number = 4
(d) Cubic close packing in three dimensions	4. Pattern of sphere is repeated in alternate layers.

Integer Type

19. The number of square faces that are present in a truncated octahedron is

20. The distance between an octahedral and tetrahedral void in pm in fcc lattice would be if edge length is 7 pm:

Comprehension Type

In hexagonal systems of crystals, a frequently encountered arrangement of atoms is described as a hexagonal prism. Here, the top and bottom of the cell are regular hexagons and three atoms are sandwiched in between them. A space-filling model of this structure, called hexagonal closepacked (HCP), is constituted of a sphere on a flat surface surrounded in the same plane by six identical spheres as closely as possible. Three spheres are then placed over the first layer so that they touch each other and represent the second layer. Each one of these three spheres touches three spheres of the bottom layer. Finally, the second layer is covered with a third layer that is identical to the bottom layer in relative position. Assume radius of every sphere to be '*r*'.

Answer the following questions:

21. The number of atoms in this HCP unit cell is:
(a) 4 (b) 6 (c) 12 (d) 17

22. The volume of this HCP unit cell is:
(a) $24\sqrt{2}r^3$ (b) $16\sqrt{2}r^3$
(c) $12\sqrt{2}r^3$ (d) $\frac{64}{3\sqrt{3}}r^3$

23. The empty space in this HCP unit cell is:
(a) 74% (b) 47.6%
(c) 32% (d) 26%

Answers Key

Subjective Type

1. (a) TiH_2 (b) TiC
2. $1.5 \times 6.023 \times 10^{23}$, $2 \times 0.5 \times 6.023 \times 10^{23}$
3. 12, 6 **4.** 26%

Single Correct Answer Type

6. (b) **7.** (a) **8.** (a) **9.** (c) **10.** (b)
11. (d) **12.** (d)

Multiple Correct Answers Type

13. (a, d) **14.** (c, d) **15.** (a, b) **16.** (c, d) **17.** (b, c)

Matching Column Type

18. (a → 3), (b → 1), (c → 4), (d → 2)

Integer Type

19. (6) **20.** (6)

Comprehension Type

21. (b) **22.** (a) **23.** (a)

DPP 1.4

Structure of Same Ionic Compounds, Coordination Number, Radius Ratio Rule, Density of Unit Cell

Subjective Type

1. Why halides of Li, Na, K and Rb do not have CsCl type lattice.
2. How temperature and pressure affect the crystal structure?
3. (i) Why is coordination number of 12 not found in ionic crystals?
   (ii) Out of NaCl and CsCl, which one is more stable and why?
4. In the cubic crystal of CsCl ($d = 3.97$ g cm^{-3}) the eight corners are occupied by Cl^- with a Cs^+ at the centre and *vice-versa*. Calculate the distance between the neighbouring Cs^+ and Cl^- ions. What is the radius ratio of the two ions? [Atomic mass of Cs = 132.91 and Cl = 35.45]

Single Correct Answer Type

5. Which one is correct about ferrites?
   (a) These possess formula AB_2O_4 (where A is divalent and B is trivalent cation)
   (b) These possess a spinel structure
   (c) $MgAl_2O_4$ is a ferrite
   (d) All of the above
6. Which of the following statements is not correct?
   (a) The co-ordination number of each type of ion in CsCl crystal is 8.
   (b) A metal that crystallizes in bcc structure has a co-ordination no. of 12.
   (c) A unit cell of ionic crystal shares some of its ions with other unit cells.
   (d) The length of the unit cell in NaCl is 552 pm ($r_{Na^+} = 95$ pm, $r_{Cl^-} = 181$ pm)
7. In antifluorite structure, the negative ions:
   (a) occupy tetrahedral voids
   (b) occupy octahedral voids
   (c) are arranged in ccp
   (d) are arranged in hcp
8. The melting point of RbBr is 682°C, while that of NaF is 988°C. The principal reason that melting point of NaF is much higher than that of RbBr is that:
   (a) the two crystals are not isomorphous
   (b) the molar mass of NaF is smaller than that of RbBr
   (c) the internuclear distance $r_c + r_a$ is greater for RbBr than for NaF
   (d) the bond in RbBr has more covalent character than the bond in NaF
9. Which of the crystals have same general formula?
   (a) Rock salt type and Anti-fluorite type
   (b) Rock salt type and Fluorite type
   (c) Fluorite type and CsCl type
   (d) Sphalerite type and Rock salt type A_4B_4 or AB.
10. Which of the following expression is correct for packing fraction of NaCl if the ions along with face are diagonally removed?
    (a) $\dfrac{\frac{13}{3}\pi r_-^3 + \frac{16}{3}\pi r_+^3}{8(r_+ + r_-)}$
    (b) $\dfrac{\frac{13}{3}\pi r_-^3 + \frac{4}{3}\pi r_+^3}{8(r_+ + r_-)^3}$
    (c) $\dfrac{\frac{16}{3}\pi r_-^3 + \frac{13}{3}\pi r_+^3}{8(r_+ + r_-)^3}$
    (d) $\dfrac{\frac{4}{3}\pi r_-^3 + \frac{13}{3}\pi r_+^3}{8(r_+ + r_-)^3}$
11. The radius of the Na^+ is 95 pm and that of Cl^- ion is 181 pm. Predict the co-ordination number of Na^+:
    (a) 4 (b) 6
    (c) 8 (d) unpredictable
12. The density of an ionic compound (molar mass 58.5) is 2.165 kg m^{-3} and the edge length of unit cell is 562 pm, then the closest distance between A^+B^- and rank of unit is:
    (a) 281 pm, 4 (b) 562 pm, 2
    (c) 562 pm, 4 (d) 281 pm, 2
13. The γ-form of iron has fcc structure (edge length 386 pm) and β-form has bcc structure (edge length 290 pm). The ratio of density in γ-form and β-form is:
    (a) 0.9788 (b) 1.02 (c) 1.57 (d) 0.6344
14. A non stoichiometric compound $Cu_{1.8}S$ is formed due to incorporation of Cu^{2+} ions in the lattice of cuprous sulphide. What percentage of Cu^{2+} ion in the total copper content is present in the compound?
    (a) 88.88 (b) 11.11 (c) 99.8 (d) 89.8
15. A binary solid (A^+B^-) has a rock salt structure. If the edge length is 400 pm and radius of cation is 75 pm the radius of anion is–
    (a) 100 pm (b) 125 pm (c) 250 pm (d) 325 pm

Multiple Correct Answers Type

16. In the unit cell of NaCl, which of the following statements are correct?
    (a) Na^+ ions have six Cl^- ions in its nearest neighbourhood
    (b) Cl^- ions have six Na^+ ions in its nearest neighbourhood
    (c) Second nearest neighbour of Na^+ ion are twelve Na^+ ions
    (d) NaCl has 68% of occupied space.

17. In which of the following solids, cations occupy tetrahedral voids?
(a) NaCl (b) CsBr (c) ZnS (d) Na_2O

18. Which of the following informations are correct about CsCl?
(a) It has body centred cubic unit cell
(b) Coordination number of both Cs^+ and Cl^- ions are eight
(c) Cl^- ions are present at body centre
(d) Cs^+ ions are present at body centre

19. Sodium oxide Na_2O is a crystalline solid. It has:
(a) antifluorite structure
(b) Na^+ ions are present at body diagonals
(c) Na^+ ions are present at tetrahedral voids
(d) O^{2-} ions are present at octahedral voids

20. Select the correct statements among the following:
(a) Nearest neighbour distance in NaCl $= \frac{a}{2}$
(b) Nearest neighbour distance in $CaF_2 = \frac{a\sqrt{3}}{4}$
(c) Nearest neighbour distance in $Na_2O = \frac{a\sqrt{3}}{4}$
(d) Nearest neighbour distance in CsCl $= \frac{a\sqrt{3}}{2}$

Matching Column Type

21. Match Column I with Column II

Column I	Column II
(a) Cations in ccp and anions in alternate tetrahedral void	(p) 6 : 6 type solid
(b) Cations in simple cubic packing and anions at body centre	(q) 4 : 4 type solid
(c) Anions in ccp and cations in all tetrahedral voids	(r) 4 : 8 type solid
(d) Cations in ccp and anions in all octahedral voids.	(s) 8 : 8 type solid

Integer Type

22. An ionic compound AB has a rock salt structure with A : B = 1 : 1. The formula mass of AB is 6.023 y amu and the closest A – B distance is $y^{1/2}$ nm. Calculate the distance of lattice.

23. In the cubic crystal of CsCl ($d = 3.97$ g cm^{-3}) the eight corners are occupied by Cl^- with a Cs^+ at the centre and *vice-versa*. What is the length of the diagonal of the cube in Å? [Atomic mass of Cs = 132.91 and Cl = 35.45]

Comprehension Type

The spinel structure consists of an array of O^{2-} ions in fcc arrangement. General formula of spinel is AB_2O_4. Cations of A occupy 1/8th of the tetrahedral voids and cations of B ions occupy half of the octahedral voids. Spinel itself is $MaAl_2O_4$. The compounds having spinel structure include some transition metal oxides like Fe_3O_4 and Mn_3O_4; in these oxides A and B are the same elements.

Spinel is also formed by Zn^{2+}, Al^{3+} and O^{2-} ions. Spinels are always electrically neutral and these are important class of compounds. There are also inverse spinels, in which the cation distribution is $B[AB]O_4$. Square bracket denotes the species in octahedral voids.

Answer the following questions:

24. Which of the following is not spinel?
(a) $FeO \cdot Fe_2O_3$ (b) $ZnO \cdot Al_2O_3$
(c) Zn_2AlO_4 (d) $MgO \cdot Al_2O_3$

25. Zn^{2+} ions will occupy:
(a) tetrahedral voids
(b) octahedral voids
(c) both tetrahedral and octahedral voids
(d) none of the voids

26. If oxide ions are replaced by $X^{-8/3}$ ions, then number of an ionic vacancy per unit cell will be:
(a) 1 (b) 2 (c) 3 (d) 4

Answers Key

Subjective Type

4. 3.57 Å, 0.73

Single Correct Answer Type

5. (d) **6.** (b) **7.** (c) **8.** (c) **9.** (d)
10. (a) **11.** (b) **12.** (a) **13.** (a) **14.** (b)
15. (b)

Multiple Correct Answers Type

16. (a, b, c) **17.** (c, d)
18. (a, b, d) **19.** (a, b, c)
20. (a, b, c, d)

Matching Column Type

21. (a → q), (b → s), (c → r), (d → p)

Integer Type

22. (5) **23.** (7)

Comprehension Type

24. (c) **25.** (a) **26.** (a)

DPP 1.5

Defects in Solids and Semiconductors

Subjective Type

1. (a) What type of semiconductor is obtained when silicon is doped with boron?
   (b) What type of point defect is produced when AgCl is doped with $CdCl_2$?
2. Silicon is an insulator but silicon doped with phosphorus acts as a semi-conductor.
3. How would you account for the following?
   (i) Frenkel defects are not found in alkali metal halides.
   (ii) Schottky defects lower the density of related solids.
4. If Al^{3+} replaces Na^+ at the edge centre of NaCl lattice then calculate the vacancies in 1 mole NaCl.

Single Correct Answer Type

5. When light strikes a photographic (AgBr) paper, silver atoms move in through these defects to:
   (a) form –ve images
   (b) form tiny clumps of silver atoms
   (c) form a colour image
   (d) none of the above
6. In a crystal some ions are missing from normal sites. This is an example of:
   (a) F-centres (b) Interstitial defect
   (c) Frenkel defect (d) Schottky defect
7. The oxide which shows transition from metal to insulation, i.e., semiconductors are:
   (a) V_2O_3 (b) VO_2 (c) Ti_2O_3 (d) all of these
8. If we mix a pentavalent impurity in a crystal lattice of germanium, what type of semiconductor formation will occur?
   (a) *p*-type (b) *n*-type
   (c) Both (a) and (b) (d) None of these
9. Which of the following represents correct order of conductivity in solids?
   (a) $\kappa_{\text{metals}} >> \kappa_{\text{insulators}} < \kappa_{\text{semiconductors}}$
   (b) $\kappa_{\text{metals}} << \kappa_{\text{insulators}} < \kappa_{\text{semiconductor}}$
   (c) $\kappa_{\text{metals}} << \kappa_{\text{semiconductor}} > \kappa_{\text{insulators}} = \text{zero}$
   (d) $\kappa_{\text{metals}} < \kappa_{\text{semiconductor}} > \kappa_{\text{insulators}} \neq \text{zero}$
10. Which of the following is true about the charge acquired by p-type semiconductors?
   (a) Positive
   (b) Neutral
   (c) Negative
   (d) Depends on concentration of *p* impurity
11. The composition of a sample of Wustite is $Fe_{0.93}O_{1.00}$. The percentage of Fe(III) ions present in the sample is about
   (a) 10% (b) 15% (c) 20% (d) 25%

Multiple Correct Answers Type

12. The correct statement(s) regarding defects in solids is (are):
   (a) Frenkel defect is usually favoured by a very small difference in the sizes of cation and anion
   (b) Frenkel defect is a dislocation defect
   (c) Trapping of an electron in the lattice leads to the formation of F-centre
   (d) Schottky defects have no effect on the physical properties of solids.
13. Which of the following is/are correct about the point defects?
   (a) In Frenkel defect, the dielectric constant of solid increases
   (b) In Schottky defect, the density of solid decreases
   (c) In Frenkel defect, the density of solid decreases
   (d) In Schottky defect, the dielectric constant of solid increases
14. The correct statement(s) for alkali halides is/are:
   (a) Metal excess defects make NaCl yellow.
   (b) Metal excess defects make LiCl, NaCl and KCl coloured.
   (c) Metal excess defects make NaCl yellow but has no effect on LiCl.
   (d) Metal excess defects make both NaCl and KCl coloured.
15. An excess of potassium ions makes KCl crystals appear violet or lilac in colour since....
   (a) some of the anionic sites are occupied by an unpaired electron
   (b) some of the anionic sites are occupied by a pair of electrons
   (c) there are vacancies at some anionic sites
   (d) F-centres are created which impart colour to the crystals
16. Which of the following defects decrease the density?
   (a) Interstitial defect (b) Vacancy defect
   (c) Frenkel defect (d) Schottky defect

Matching Column Type

17. Match the Column I with Column II.

Column I	Column II
(a) NaCl	(p) Schottky defect
(b) ZnS	(q) Frenkel defect
(c) AgBr	(r) Develops yellow colour on heating due to F-centre
(d) KCl	(s) Develops blue/violet colour on heating due to F-centre

Integer Type

18. Calcium crystallizes in fcc unit cell with 0.500 nm. Calculate the density if it contains 0.1% Schottky defect.

19. If an element (at. wt. = 40) crystallizes in fcc lattice, with $a = 0.50$ nm. What is the density of unit cell if it contains 0.25% Schottky defects (use $N_A = 6 \times 10^{23}$)?

Comprehension Type

Doping a silicon crystal with a group-13 element (with three valence electrons) such as B, Al, Ga or In produces a semiconductor with three electrons in dopant. The place where fourth electron is missing is called an electron vacancy or hole.

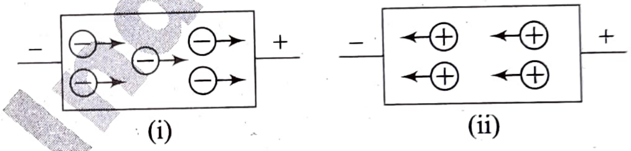
Answer the following questions:

20. Silicon that has been doped with group-15 elements is called
(a) *p*-type semiconductor
(b) *n*-type semiconductor
(c) electron vacancy or hole
(d) *e*-type semiconductor

21. Silicon that has been doped with group-13 elements is called
(a) *p*-type semiconductor
(b) *n*-type semiconductor
(c) electron vacancy or hole
(d) *e*-type semiconductor

22. If NaCl is doped with 10^{-3} mol % $SrCl_2$, then concentration of cation vacancies is
(a) 6.02×10^{23} (b) 6.02×10^{20}
(c) 6.02×10^{18} (d) 6.02×10^{15}

23. What are the types of the following semiconductors I and II?



(i) (ii)

(a) I *p*-type, II *n*-type (b) I *n*-type, II *p*-type
(c) Both *n*-type (d) Both *p*-type

Answers Key

Single Correct Answer Type

5. (b) **6.** (d) **7.** (d) **8.** (b) **9.** (a)
10. (b) **11.** (b)

Multiple Correct Answers Type

12. (b, c) **13.** (a, b) **14.** (a, b, d)
15. (a, d) **16.** (b, d)

Matching Column Type

17. (a → p, r), (b → q), (c → p, q), (d → p, s)

Integer Type

18. (2) **19.** (2)

Comprehension Type

20. (b) **21.** (a) **22.** (c) **23.** (b)

DPP 1.6

Magnetism and Bragg's Equation

Subjective Type

1. What happens when ferromagnetic Fe_3O_4 is heated to 850 K and why?
2. (a) What is levitation?
   (b) In what condition, mercury starts behaving as a superconductor?
3. The length of a unit cell in the nickel crystal is 0.352 nm. Diffraction of X-rays of 0.154 nm wavelength from a nickel crystal occurs at 22.2°, 25.9°, and 38.2°. Show that these data are consistent with a face-centered cubic crystal structure.
4. Which oxide is used to make magnetic tapes? Which kind of magnetism is shown by this oxide?

Single Correct Answer Type

5. Ferrimagnetic is converted into paramagnetic at:
   (a) 300 K (b) 400 K (c) 600 K (d) 850 K
6. Which of the following statements are true?
   (a) Piezo-electricity is due to net dipole moment
   (b) Ferro-electricity is due to alignment of dipoles in same direction
   (c) Pyro-electricity is due to heating polar crystals
   (d) All of the above
7. Which arrangement of electron decides ferrimagnetism?
   (a) ↑↑↑↑↑ (b) ↑↓↑↓
   (c) ↑↑↑↓↓ (d) None of these
8. At what angles for the first order diffraction, spacing between two planes respectively are λ and $\frac{\lambda}{2}$?
   (a) 0°, 90° (b) 90°, 0°
   (c) 30°, 90° (d) 90°, 30°
9. Which substance shows antiferromagnetism?
   (a) ZnO_2 (b) CdO
   (c) CrO_2 (d) MnO_3
10. Which of the following relation is correct for first order Bragg's diffraction?
   (a) $\sin\theta = \frac{2a}{\lambda}(h^2 + k^2 + l^2)$
   (b) $\sin\theta = \frac{2a}{\lambda}(h^2 + k^2 + l^2)^{1/2}$
   (c) $\sin\theta = \frac{\lambda}{2a}(h^2 + k^2 + l^2)^{1/2}$
   (d) $\sin\theta = \frac{\lambda}{2a}(h^2 + k^2 + l^2)^2$
11. The oxide which shows metallic conduction is:
   (a) ReO_3 (b) VO (c) CrO_2 (d) all of these

Multiple Correct Answers Type

12. Which of the following statements are correct about the diamagnetic solids?
   (a) They have only paired electrons
   (b) They are weakly repelled in magnetic field
   (c) They have large number of unpaired electrons
   (d) Chromium is diamagnetic
13. Superconductors are technologically and commercially important substances. The correct information(s) about such conductors are:
   (a) phenomena of superconductivity was first discovered by Kammerlingh and Onnes
   (b) mercury acts as superconductor at 4 K
   (c) superconductors offer zero resistance and zero kelvin
   (d) gallium acts as superconductor at 4 K
14. The value of magnetic moment is zero in the case of antiferromagnetic substances because the domains....
   (a) get oriented in the direction of the applied magnetic field
   (b) get oriented opposite to the direction of the applied magnetic field
   (c) are oppositely oriented with respect to each other without the application of magnetic field
   (d) cancel out each other's magnetic moment
15. Which of the following statements are correct?
   (a) Ferrimagnetic substances lose ferrimagnetism on heating and become paramagnetic
   (b) Ferrimagnetic substances do not lose ferrimagnetism on heating and remain ferrimagnetic
   (c) Antiferromagnetic substances have domain structures similar to ferromagnetic substances and their magnetic moments are not cancelled by each other
   (d) In ferromagnetic substances, all the domains get oriented in the direction of magnetic field and remain as such even after removing the magnetic field

16. What will be the wavelength of X-rays which give a diffraction angle $(2\theta) = 16.80°$ for a crystal if the interplanar distance in the crystal is 0.200 nm and only first order diffraction is observed $(\sin 8.40° = 0.1461)$?
(a) 584 pm (b) 584 nm
(c) 58.4 pm (d) 65.8 pm

Matching Column Type

17. Match the column:

Column I	Column II
(a) Antipiezoelectricity	(p) Used in fire alarms, and thermostate
(b) Ferroelectricity	(q) Crystal suffers elastic deformation in an electric field
(c) Pyroelectricity	(r) Charges are developed in some part of crystal
(d) Piezoelectricity	(s) Possess by piezoelectric crystals having permanent dipoles

Integer Type

18. Bragg's equation:
X-rays of wavelength 1.54 Å strike a crystal and are observed to be deflected at an angle of 22.5°. Assuming that $n = 1$, calculate the spacing between the planes of atoms that are responsible for this reflection.

19. For $\theta = 30°$, Bragg's equation is found to be d(edge length) $= 4\lambda$. What is the order of diffraction?

Comprehension Type

Superconductivity or superconduction is of two types, viz., low temperature superconductivity and high temperature superconductivity.

At very low temperatures, many metals, alloys and certain compounds become superconductors. They also exhibit Meissner effect: it states that a superconductor does not allow the magnetic field to pass through it. The Meissner effect gives rise to levitation. The HTSC are related to the pervoskite structure. An example of HTSC is $YBa_2Cu_3O_{7-x}$ $(x < 0.1)$.

Answer the following questions:

20. Superconductors are:
(a) paramagnetic substance
(b) ferromagnetic substance
(c) diamagnetic substance
(d) None of these

21. Levitation is achieved by
(a) mutual repulsion between permanent magnet and a super conductor
(b) mutual repulsion between a weak magnet and a superconductor
(c) a slight attraction between a permanent magnet and a superconductor
(d) None of these

22. Which one possess pervoskite structure?
(a) $BaTiO_4$ (b) $NaMgF_3$
(c) $BaTiO_2$ (d) $NaMg_3F$

Answers Key

Single Correct Answer Type

5. (d) **6.** (d) **7.** (c) **8.** (c) **9.** (d)
10. (c) **11.** (d)

Multiple Correct Answers Type

12. (a, b) **13.** (a, b, c)
14. (c, d) **15.** (a, d)
16. (c)

Matching Column Type

17. (a → q), (b → s), (c → p), (d → r)

Integer Type

18. (2) **19.** (4)

Comprehension Type

20. (c) **21.** (a) **22.** (b)

CHAPTER 2

Solutions

DPP 2.1

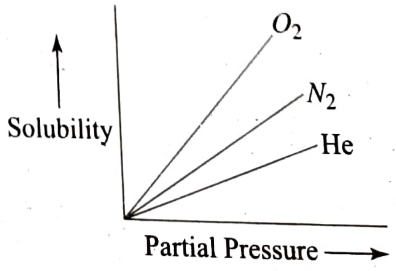
Concentration Terms, Vapour Pressure and Henry's Law

Subjective Type

1. What is the purity of conc. H_2SO_4 solution (specific gravity 1.8 g/mL), if 50 mL of this solution is neutralized by 84.6 mL of 2.0 N NaOH?
2. Why are aquatic species more comfortable in cold water in comparison to warm water?
3. On dissolving sugar in water at room temperature solution feels cool to touch. For dissolution of sugar to be rapid what should be taken—
   (i) Powdered sugar or sugar crystal
   (ii) Hot water or cold water
4. 109% labeled oleum has x mole of H_2SO_4 and y mole of SO_3 respectively. What is the value of $\left(\frac{x+y}{x-y}\right)$ in oleum?
5. A sample of drinking water was contaminated with arsenic, a poisonous material for body. The level of contamination was 15 ppm. What is the concentration of arsenic in water in terms of % by mass and molality?
6. (i) Calculate the concentration of CO_2 in a soft drink that is bottled with a partial pressure of CO_2 of 4 atm over the liquid at 25°C. The Henry's law constant for CO_2 in water at 25°C is 3.1×10^{-2} mol/litre-atm.
   (ii) If N_2 is bubbled through water at 293 K, how many milli moles of N_2 gas would dissolve in 1 litre of water? Assume that N_2 exerts a partial pressure of 0.987 bar. Given, that Henry's law constant for N_2 at 293 K is 76.481 bar.

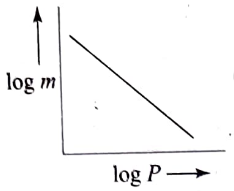
Single Correct Answer Type

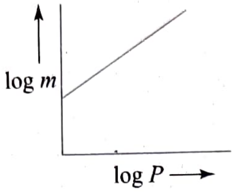
7. Which of the following units is useful in relating concentration of solution with its vapour pressure?
   (a) Mole fraction (b) Parts per million
   (c) Mass percentage (d) Molality
8. The volume required to prepare 2.0 L of 3.0 m H_2SO_4 solution from 96% H_2SO_4 solution (density 1.83 g mL^{-1}) is
   (a) 242.0 mL (b) 334.7 mL
   (c) 385.2 mL (d) 450.1 mL
9. The normality of 0.3 M phosphorous acid is:
   (a) 0.1 (b) 0.9 (c) 0.3 (d) 0.6
10. What mass of ethanol be added to 1.0 g water to have the mole fraction of ethanol equal to 0.20?
    (a) 63.89 g (b) 6.39 g
    (c) 638.89 g (d) 683.89 g
11. Molar solubility of helium, nitrogen and oxygen are plotted against partial pressure of the gas at constant temperature. Henry's law constant for these gases will lie in following sequence?

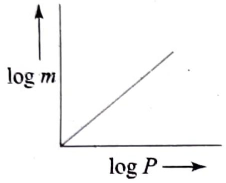


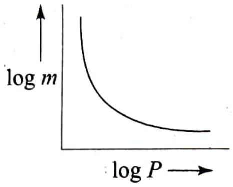
(a) $O_2 > N_2 > He$ (b) $O_2 < N_2 < He$
(c) $O_2 = N_2 = He$ (d) $O_2 > N_2 < He$

12. According to William Henry, the solubility of a gas in liquid depends on the pressure of the gas. If 'm' is the molality of the gas and 'P' is its pressure, then which of the following plot is in accordance with the law?

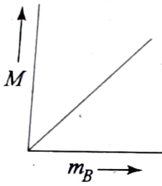
(a) 

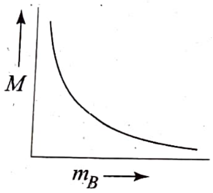
(b) 

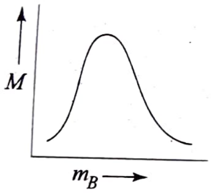
(c) 

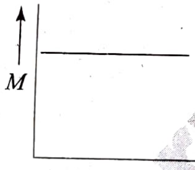
(d) 

13. Which of the following plot is correct for solutions of different solutes, having same density?

(a) 

(b) 

(c) 

(d) 

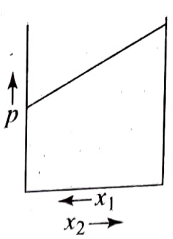
14. The molarity of a solution obtained by mixing 750 mL of 0.5 M HCl with 250 mL of 2M HCl will be:
(a) 1.75 M (b) 0.975 M
(c) 0.875 M (d) 1.00 M

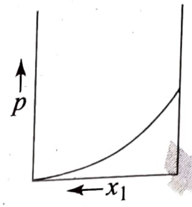
Multiple Correct Answers Type

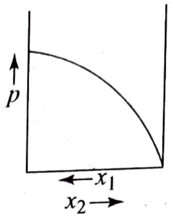
15. The vapour pressure of a dilute solution of a solute is influenced by:
(a) temperature of solution
(b) mole fraction of solute
(c) melting point of solute
(d) degree of dissociation of solute

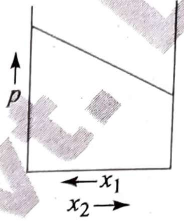
16. By adding water to the solution of ionic compound its:
(a) concentration remains same
(b) concentration increases
(c) ionization may increase
(d) concentration decreases

17. For a binary ideal liquid solution, the variation in total vapour pressure versus composition of solution is given by which of the curves?

(a) 

(b) 

(c) 

(d) 

18. 5.3% (W/V) Na_2CO_3 solution and 6.3% (W/V) $H_2C_2O_4 \cdot 2H_2O$ solution have same
(a) Molality (b) Molarity
(c) Normality (d) Mole fraction

19. Which of the following conversion is/are correctly depicted? The symbols used are m = molality of the solution; M = molarity of the solution; x_1 and x_2 = mole fractions of solvent and solute respectively. M_1 and M_2 = molar masses of solvent and solute respectively. ρ = density of solution. n_1 and n_2 = amounts of the solvent and solute respectively.
(a) $m = M/(\rho - MM_2)$ (b) $M = (1 + mM_2)/m\rho$
(c) $x_2 = mM_1\ (1 + mM_1)$ (d) $M = x_2\rho/(x_1M_1 + x_2M_2)$

Matching Column Type

20. Match the items given in column I with the type of solutions given in column II.

Column I	Column II
A. Soda water	1. A solution of gas in solid
B. Sugar solution	2. A solution of gas in gas
C. German silver	3. A solution of solid in liquid
D. Air	4. A solution of solid in solid
E. Hydrogen gas in palladium	5. A solution of gas in liquid
	6. A solution of liquid in solid

Integer Type

21. Air contains O_2 and N_2 in the ratio of 1:4. Calculate the ratio of solubilities in terms of mole fractions of N_2 and O_2 dissolved in water at atmospheric pressure and room temperature at which Henry's constant for O_2 and N_2 are 3.30×10^7 torr and 6.60×10^7 torr respectively.

22. A 5.37 M solution of KOH in water contains 30% by mass of KOH. Calculate the density of the KOH solution. (Molar mass of KOH = 56 g mol^{-1})

Comprehension Type

Henry's law gives a quantitative relationship between the solubility of gas and the pressure. This law states that at a given temperature the mass of dissolved gas in a given volume of solvent is proportional to the pressure of the gas with which it is in equilibrium.

Choose the incorrect option:

23. Henry's law is valid only when:
  (a) pressure is low
  (b) temperature is high
  (c) the gas is not highly soluble
  (d) the gas neither reacts chemically with the solvent nor dissociates or associates in the solvent.

24. At same temperature, oxygen is more soluble is water than hydrogen. Which of them will have a higher value of K_H?
  (a) Oxygen
  (b) Hydrogen
  (c) Both will have equal value
  (d) Can't predict

25. Henry's law constant for the solubility of N_2 gas in water at 298 K is 1.0×10^5 atm. The mole fraction of N_2 in air is 0.6. The number of moles of N_2 from air dissolved in 10 moles of water at 298 K and 5 atm pressure is
  (a) 3.0×10^{-4} (b) 4.0×10^{-5}
  (c) 5.0×10^{-4} (d) 6.0×10^{-6}

Answers Key

Subjective Type

1. 92.12% **4.** 9.91
6. (i) 0.124 mol/litre (ii) 0.718

Single Correct Answer Type

7. (a) **8.** (b) **9.** (d) **10.** (c) **11.** (b)
12. (b) **13.** (b) **14.** (c)

Multiple Correct Answers Type

15. (a, b, d) **16.** (c, d) **17.** (a, d) **18.** (b, c) **19.** (a, b, d)

Matching Column Type

20. (A → 5), (B → 3), (C → 4), (D → 2), (E → 1)

Integer Type

21. (2) **22.** (1)

Comprehension Type

23. (b) **24.** (b) **25.** (a)

DPP 2.2

Raoult's Law, Ideal and Non-Ideal Solution, Azeotrops

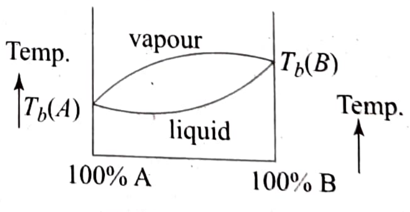
Subjective Type

1. Components of a binary mixture of two liquids A and B were being separated by distillation. After some time separation of components stopped and composition of vapour phase became same as that of liquid phase. Both the components started coming in the distillate. Explain why this happened?
2. Cyclohexane and ethanol at a particular temperature have vapour pressure of 280 mm and 168 mm respectively. If these two solutions having mole fraction value of cyclohexane equal to 0.32 are mixed and the mixture has a total vapour pressure of 376 mm, will the mixture be an ideal solution?
3. Benzene and toluene form two ideal solutions A and B at 313 K. Solution A contains 4 mole of toluene and one mole of C_6H_6. Solution B contains equal masses of toluene and benzene. Calculate total pressure in each case. The vapour pressure of C_6H_6 and toluene are 160 nm and 60 mm respectively at 313 K.
4. The vapour pressure of pure ethylene bromide and propylene bromide are 170 mm and 127 mm of Hg at a temperature. Find out the vapour pressure of ethylene bromide in a 60% by mass solution of ethylene bromide in propylene bromide at same temperature. Also report the vapour pressure of propylene bromide as well as total vapour pressure of solution.
5. Considering the formation, breaking and strength of hydrogen bond, predict why mixture of methanol and acetone will show a positive deviation from Raoult's law and mixture of chloroform and acetone show –ve deviation.

Single Correct Answer Type

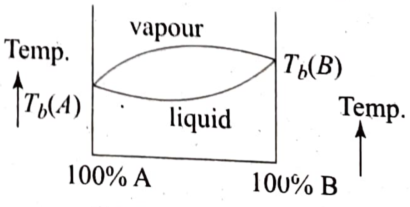
6. An ideal solution has two components A and B. If A is more volatile than B and also $P_A^o > P_T$, then the correct relation between mole fraction of A in liquid (X) and vapour (Y) phase is:
   (a) $X_A = Y_A$ (b) $X_A > Y_A$
   (c) $X_A < Y_A$ (d) Nothing can be said
7. A solution has 1 : 4 mole ratio of pentane to hexane. The vapour pressure of pure hydrocarbons at 20°C are 440 mm Hg for pentane and 120 mm Hg for hexane. The mole fraction of pentane in vapour phase would be:
   (a) 0.786 (b) 0.549 (c) 0.478 (d) 0.200
8. The vapour pressure of two liquids P and Q are 80 torr and 60 torr respectively. The total vapour pressure obtained by mixing 3 mole of P and 2 mole of Q would be
   (a) 68 torr (b) 20 torr (c) 140 torr (d) 72 torr
9. A maxima or minima obtained in the temperature, composition curve of a mixture of two liquids indicates:
   (a) an azeotropic mixture
   (b) an eutectic formation
   (c) that the liquids are immiscible with one another
   (d) that the liquids are partially miscible at the maximum or minimum
10. The lubricating action of an oil is more if it possess:
    (a) high vapour pressure (b) low vapour pressure
    (c) high surface tension (d) high density
11. The boiling point of C_6H_6, CH_3OH, $C_6H_5NH_2$ amd $C_6H_5NO_2$ are 80°C, 65°C, 184°C and 212°C respectively. Which will show highest vapour pressure at room temperature?
    (a) C_6H_6 (b) CH_3OH
    (c) $C_6H_5NH_2$ (d) $C_6H_5NO_2$
12. At 40°C, the vapour pressure (in torr) of methyl alcohol (A) and ethyl alcohol (B) solution is represented by: $P = 120\,X_A + 138$; where X_A is mole fraction of methyl alcohol. The value of $\lim\limits_{X_A \to 0} \frac{P_B^o}{X_B}$ and $\lim\limits_{X_B \to 0} \frac{P_A^o}{X_A}$ are:
    (a) 138, 258 (b) 258, 138
    (c) 120, 138 (d) 138, 125
13. When a plot of boiling point versus composition is plotted, then the type of graph that can be obtained is:

(a)



(% Composition)
For ideal solution with $p_A^0 > p_B^0$

(b)



(% Composition)
For ideal solution with $p_A^0 < p_B^0$

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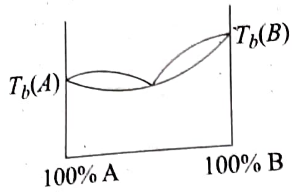
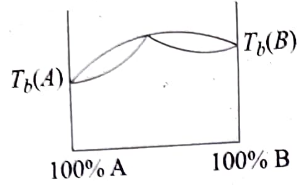
(c)



(% Composition)
Non-ideal solution
with positive deviation

(d)



(% Composition)
Non-ideal solution
with negative deviation

14. Which of the following graphs represent the behaviour of ideal binary liquid mixture?

(a) Plot of $1/P_{\text{Total}}$ against y_A is linear
(b) Plot of $1/P_{\text{Total}}$ against y_B is linear
(c) Plot of P_{Total} against y_A is linear
(d) Plot of P_{Total} against y_B is linear
(Here, y_A and y_B are the mole fraction of components A and B in vapour).

Multiple Correct Answers Type

15. On mixing 1 mole of $C_6H_6 (P^0 = 42 \text{ mm})$ and 2 mole of C_7H_8 $(P^0 = 36 \text{ mm})$, one can conclude:

(a) total vapour pressure of mixture = 38 mm
(b) mole fraction of vapours of C_6H_6 above liquid mixture $= \frac{7}{19}$
(c) positive deviation from Raoult's law
(d) ideal solution of two

16. Benzene and naphthalene form an ideal solution at room temperature. For this process, the true statement(s) is (are):

(a) ΔG is positive
(b) ΔS_{system} is positive
(c) $\Delta S_{\text{surroundings}} = 0$
(d) $\Delta H = 0$

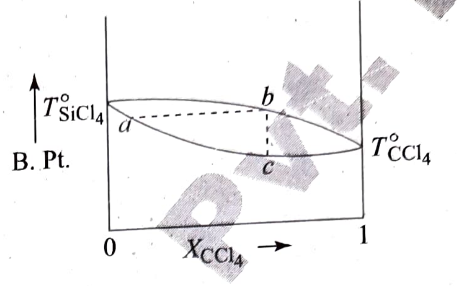
17. Which of the following statements is/are false for a solution of chloroform and acetone?

(a) The solution formed is an ideal solution
(b) The solution formed is a non-ideal solution with positive deviation from Raoult's law
(c) The solution formed is a non-ideal solution with negative deviation from Raoult's law
(d) The solution behaves ideally or non-ideally depending upon its composition.

18. Composition of an azeotrope

(a) is independent of external pressure because it is a compound
(b) alters on changing the external pressure as it is not a compound
(c) remains unchanged during distillation at a constant external pressure
(d) fluctuates even at constant pressure

19. The diagram given below depicts the boiling point as the function of composition of the mixture of CCl_4 and $SiCl_4$. Which of the following statements about the diagram is/are true?



(a) The point a represents the composition of solution and the point b that of the vapour in equilibrium
(b) The proportion of CCl_4 in the solution is smaller than that in the vapour in equilibrium
(c) bc represents the condensation of the vapour
(d) The point c represents the composition of solution and the point b that of the vapour in equilibriums.

Matching Column Type

20. Match the following:

Column I	Column II
A. Carbon tetrachloride + Toluene	p. Shows positive deviation from ideal behaviour
B. Chloroform + Benzene	q. Shows negative deviation from ideal behaviour
C. Carbon tetrachloride + Chloroform	r. Mixing is endothermic
D. Benzene + Toluene	s. Shows ideal behaviour

Integer Type

21. A mixture of two immiscible liquids nitrobenzene and water boiling at 99°C has a partial pressure of water 733 mm and of nitrobenzene 27 mm. The ratio of mass of water and nitrobenzene in mixture is ....

22. The vapour pressure of two liquids A and B are 50 mm and 100 mm respectively. The ratio of mole fractions of B and A in vapour phase over the liquid if they are mixed in 1 : 1 ratio is ......

Comprehension Type

According to Raoult's law, partial pressure of any volatile constituent of a solution at a constant temperature is equal to the vapour pressure of pure constituent multiplied by mole-fraction of that constituent in the solution.

This law is the major deciding factor whether a solution will be ideal or non-ideal. Ideal solution always obey Raoult's law at energy range of concentration.

A liquid mixture of benzene and toluene is composed of 1 mol of benzene and 1 mol of toluene. Benzene and toluene mixture behave ideally. Given $p_t^0 = 4.274$ KN/m^2; $p_b^0 = 13.734$ KN/m^2 where subscript t and b stands for toluene and benzene respectively.

23. If pressure over mixture at 300 K is reduced, at what pressure does the first vapour form?
(a) 18.008 KN/m^2 (b) 9.004 KN/m^2
(c) 13.05 KN/m^2 (d) 3.003 KN/m^2

24. What is the composition of first trace of vapour formed i terms of mole-fraction of toluene?
(a) 0.2373 (b) 0.7627
(c) 0.333 (d) 0.67

25. If the pressure is further reduced, at what pressure doe last trace of liquid disappear?
(a) 9.004 KN/m^2 (b) 6.519 KN/m^2
(c) 3.03 KN/m^2 (d) None of these

26. What will be the mole-fraction of toluene in last trace o liquid?
(a) 0.2373 (b) 0.7627
(c) 0.333 (d) 0.67

Answers Key

Single Correct Answer Type

6. (c) **7.** (c) **8.** (d) **9.** (a) **10.** (b)
11. (b) **12.** (a) **13.** (b) **14.** (a)

Multiple Correct Answers Type

15. (a, b, d) **16.** (b, c, d) **17.** (a, b, d)
18. (b, c) **19.** (a, b, c)

Matching Column Type

20. (A → p, r), (B → q), (C → p, r), (D → s)

Integer Type

21. (4) **22.** (2)

Comprehension Type

23. (b) **24.** (a) **25.** (b) **26.** (b)

DPP 2.3

Relative Lowering in Vapour Pressure and Elevation in Boiling Point

Subjective Type

1. Explain why on addition of 1 mole of NaCl to 1 L of water, the boiling point of water increases, while addition of 1 mole of methyl alcohol to 1 L of water decreases its boiling point.
2. Why is the vapour pressure of an aqueous solution of glucose lower than that of water?
3. (i) 2 g each of two solutes A and B (molar mass of A is greater that of B) are dissolved separately in 50 g each of the same solvent. Which will show greater elevation in the boiling point?
   (ii) An aqueous solution containing 288 g of a nonvolatile compound having the stoichiometric composition $C_nH_{2n}O_n$ in 90.0 g of water boils at 101.24°C at 1.00 atm pressure. What is the molecular formula of the compound?
4. A solution contains 30 g of a non-volatile solute in exactly 90 g water has a vapour pressure 21.85 mm of Hg at 25°C. Further 18 g of water is then added to solution, the new vapour pressure becomes 22.15 mm of Hg at 25°C. Calculate,
   (a) Molar mass of solute
   (b) Vapour pressure of water at 25°C.
5. What mass of non-volatile solute, urea (NH_2CONH_2) needs to be dissolved in 100 g of water, in order to decrease the vapour pressure of water by 25%. What will be the molality of solution?

Single Correct Answer Type

6. Molal elevation constant of a liquid is:
   (a) the elevation in b.p. which would be produced by dissolving one mole of solute in 100 g of solvent
   (b) the elevation of b.p. which would be produced by dissolving 1 mole solute in 10 g of solvent
   (c) elevation in b.p. which would be produced by dissolving 1 mole of solute in 1000 g of solvent
   (d) none of the above
7. The vapour pressure of a solution of a non-volatile electrolyte (A) in a solvent (B) is 95% of the vapour pressure of the solvent at the same temperature. If $M_B = 0.3\, M_A$, where M_B and M_A are molar masses of B and A respectively, the mass ratio of the solvent and solute are:
   (a) 0.15 (b) 5.7 (c) 0.2 (d) 4.0
8. Elevation in boiling point of an aqueous glucose solution is 0.6, K_b for water is 0.52 K molality^{-1}. The mole fraction of glucose in the solution is :
   (a) 0.02 (b) 0.03 (c) 0.01 (d) 0.04
9. Normal boiling point (T_N) is defined as the temperature when V.P. of liquid becomes equal to 1 atm and standard boiling point (T_S) is defined as the temperature when V.P. of liquid becomes equal to 1 bar. Which one is not correct if water is considered?
   (a) $T_N = 100°C$ (b) $T_S > 100°C$
   (c) $T_S < 100°C$ (d) $T_S < T_N$
10. Y gm of a non-volatile solute of molar mass M is dissolved in 250 g of benzene. If K_b is molal elevation constant, the value of ΔT is given by:
   (a) $\frac{4M}{K_bY}$ (b) $\frac{4K_bY}{M}$ (c) $K_b\frac{Y}{4M}$ (d) $K_b\frac{Y}{M}$
11. The vapour pressure of pure liquid A is 10 torr and at the same temperature when 1 g of B solid is dissolved in 20 g of A, its vapour pressure is reduced to 9.0 torr. If the molecular mass of A is 200 amu, then the molecular mass of B is
   (a) 100 amu (b) 90 amu
   (c) 75 amu (d) 120 amu
12. Calculate the ebullioscopic constant for water. The heat of vaporization is 40.685 kJ mol^{-1}.
   (a) 0.512 K kg mol^{-1} (b) 1.86 K kg mol^{-1}
   (c) 5.12 K kg mol^{-1} (d) 3.56 K kg mol^{-1}
13. An aqueous solution of urea is found to boil at 100.52°C. Given K_b for water is 0.52 K kg mol^{-1}, the mole fraction of urea in the solution is
   (a) 1 (b) 0.5 (c) 0.018 (d) 0.25

Multiple Correct Answers Type

14. When common salt is dissolved in water, the:
   (a) melting point of the solution increases
   (b) boiling point of the solution increases
   (c) vapour pressure of the solution decreases
   (d) None of these
15 For a non-volatile solute
   (a) The vapour pressure of a solute is zero.
   (b) Vapour pressure of solution = Vapour pressure of pure solvent

(c) Vapour pressure of solution = Vapour pressure of solvent in solution.

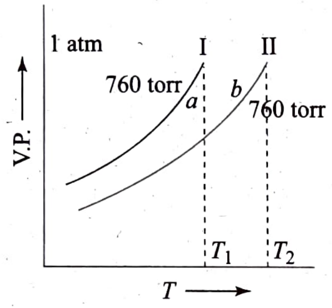
(d) All of the above.

16. If P^0 and P_S are the V.P. of solvent and solution respectively and N_1 and N_2 are the mole of solute and solvent, then:

(a) $\frac{(P^0 - P_S)}{P^0} = \frac{N_1}{(N_1 + N_2)}$ (b) $\frac{(P^0 - P_S)}{P_S} = \frac{N_1}{N_2}$

(c) $\frac{(P^0 - P_S)}{P^0} = \frac{N_1}{N_2}$ (d) none of these

17. Vapour pressure – temperature curves of pure solvent and a solution containing a non-volatile solute are depicted in the figure aside. Select the correct statement(s) of the following.



(a) Curve I represents the variation of vapour pressure of solution and II that of solvent with temperature

(b) Curves I and II represent the variation of vapour pressures of solvent and solution respectively with temperature

(c) Gap *ab* represents K_bm for the solution

(d) Gap *ab* represents K_cm for the solution.

18. The ebulioscopic constant depends upon

(a) the molar mass of the solute in the solution

(b) the molar mass of the solvent in the solution

(c) the enthalpy of vaporization of the solvent

(d) the boiling point of solvent

Matching Column Type

19. Dry air is passed repeatedly through a solution of a non-volatile solute in water and then through pure water at the same temperature.

Given that:

Loss in mass of solution = w_1g

Vapour pressure of solution = p_s

Loss in mass of water = w_2g

Vapour pressure of water = $p°$

Column I	Column II
A. $w_1 \propto$	p. $(p° - p_s)$
B. $w_2 \propto$	q. p_s
C. $(w_1 + w_2) \propto$	r. $(p° - p_s)/p°$
D. $w_2/(w_1 + w_2) \propto$	s. $p°$

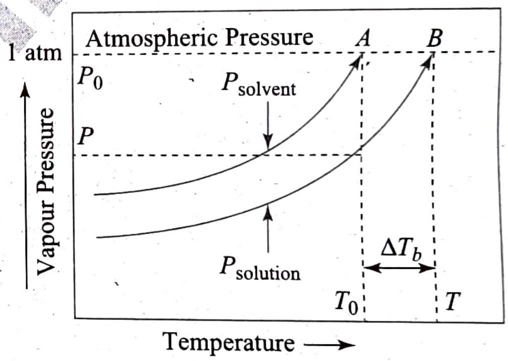
Integer Type

20. '*n*' mole of a non-electrolyte are added to '*N*' mole of solvent. The addition causes a lowering in vapour pressure of solvent by 20%. The ratio of mole of solvent and its solute is …

21. The mass of a non-volatile solute of molar mass 40 g mol^{-1}, which on dissolution in 57 g octane to reduce the vapour pressure of octane by 20% is …

Comprehension Type

Figure explains elevation in boiling point when a non-volatile solute is added to a solvent.



22. Given that ΔT_b is the elevation in boiling point of the solvent in a solution of molality '*m*', then $\lim_{m \to 0} \left(\frac{\Delta T_b}{m} \right)$ is equal to –

(a) K_b (molal elevation constant)

(b) L_y (latent heat of vaporisation)

(c) ΔS (entropy change)

(d) X (mole fraction of solute)

23. Elevation in b.p. of an aqueous urea solution is 0.52°. (K_b = 0.52° mol^{-1} kg). Hence, mole fraction of urea in this solution is

(a) 0.982 (b) 0.0567 (c) 0.943 (d) 0.018

Answers Key

Subjective Type

4. (a) 67.83 g mol^{-1} (b) 23.78 mm

5. 111.11 g, 18.52 m

Single Correct Answer Type

6. (c) **7.** (b) **8.** (a) **9.** (b) **10.** (b)

11. (b) **12.** (a) **13.** (c)

Multiple Correct Answers Type

14. (b, c) **15.** (a, c) **16.** (a, b) **17.** (b, c) **18.** (b, c, d)

Matching Column Type

19. (A → p), (B → p), (C → s), (D → r)

Integer Type

20. (4) **21.** (5)

Comprehension Type

22. (a) **23.** (d)

DPP 2.4

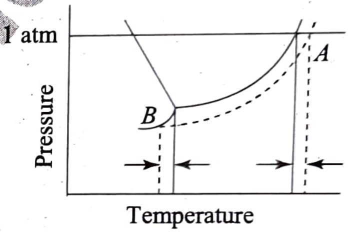
Depression in Freezing Point

Subjective Type

1. How does sprinkling of salt help in clearing the snow covered roads in hilly area? Explain the phenomenon involved in the process.
2. If glycerine, $C_3H_5(OH)_3$, and methyl alcohol, CH_3OH, sell at the same price per pound, which would be cheaper for preparing an antifreeze solution for the radiator of an automobile?
3. Camphor, $C_{10}H_{16}O$, which has a freezing point of 174°C, has a freezing point depression constant of 40.0°C/m. Explain the usefulness and the limitations of camphor as a solvent for determination of molecular weights. For what kind(s) of solutes would camphor be especially useful?
4. A certain solution of benzoic acid in benzene has a freezing point of 3.1°C and a normal boiling point of 82.6°C. Explain these observations, and suggest structures for the solute particles at the two temperatures.

Single Correct Answer Type

5. The value of K_f for water is 1.86°, calculated from glucose solution. The value of K_f for water calculated for NaCl solution will be:
(a) = 1.86 (b) < 1.86 (c) > 1.86 (d) zero
6. In which case depression freezing point is equal to cryoscopic constant for water :
(a) 6 % by mass of urea in aqueous solution
(b) 100 g of sucrose in 100 mL solution
(c) 9 g of urea in 59 g aqueous solution
(d) 1 M KCl solution
7. The amount of urea to be dissolved in 500 cc of water (K_f = 1.86) to produce a depression of 0.186°C in the freezing point is:
(a) 9 g (b) 6 g (c) 3 g (d) 0.3 g
8. Freezing point of an aqueous solution is −0.186°C. Elevation of boiling point of same solution would be: (K_b = 0.512 and K_f = 1.86 K molality^{-1})
(a) 0.186°C (b) 0.0512°C
(c) 0.092°C (d) 0.237°C
9. The amount of ice that will separate out on cooling a solution containing 50 g of ethylene glycol in 200 g water to −9.3°C is: (K'_f = 1.86 K molality^{-1})
(a) 38.71 g (b) 38.71 mg
(c) 42 g (d) 42 mg
10. What should be the freezing point of aqueous solution containing 17 g of C_2H_5OH in 1000 g of water (K_f for water = 1.86 deg kg mol^{-1})?
(a) − 0.69°C (b) 0.34°C
(c) 0.0°C (d) − 0.34°C
11. The phase diagrams for a pure solvent (represented by the solid line) and a corresponding solution (containing a nonvolatile solute and represented by the dashed lines) are shown below.



Choose the correct option.
(a) $A = \Delta T_b\, m$ and $B = \Delta T_f\, m$
(b) $A = \Delta T_f\, m$ and $B = \Delta T_b\, m$
(c) $A = \Delta T_f$ and $B = \Delta T_b$
(d) $A = \Delta T_b$ and $B = \Delta T_f$
where T_f, T_b and m stand for freezing point temperature, boiling point temperature and molality.

Multiple Correct Answers Type

12. In the depression of freezing point experiment, it is found that
(a) The vapour pressure of the solution is less than that of pure solvent
(b) The vapour pressure of the solution is more than that of pure solvent
(c) Only solute molecules solidify at the freezing point
(d) Only solvent molecules solidify at the freezing point.
13. A solution of urea (mol mass 56 g mol^{-1}) boils at 100.18°C at atmospheric pressure. If K_f and K_b for water are 1.86 K kg mol^{-1} and 0.512 K kg mol^{-1} respectively, the above solution will not freeze at
(a) −6.54°C (b) −0.654°C
(c) 6.54°C (d) 0.654°C
14. Which of the following statement(s) is/are not correct when mercuric iodide is added to the aqueous solution of potassium iodide?

(a) Freezing point is raised
(b) Freezing point is lowered
(c) Freezing point does not change
(d) Boiling point does not change

15. Which of the following is/are not linked to the lowering of vapour pressure by a non-volatile solute?
(a) boiling point elevation
(b) freezing point depression
(c) solubility
(d) surface tension

Matching Column Type

16. ΔH_f = Molar heat of fusion of ice; L_f = Latent heat of fusion of ice (g^{-1})
ΔH_v = Molar heat of vaporization of water; L_v = Latent heat of vaporization of water (g^{-1})
Match the following appropriately:

Column I	Column II
A. Molal depression constant of water	p. $\dfrac{18 \times 373 \times 373 \times R}{1000 \Delta H_v}$
B. Molal elevation constant of water	q. $\dfrac{373 \times 373 \times R}{1000 L_v}$
C. ΔT_f of solution containing 9.0 g of glucose in 50 g of water	r. $\dfrac{18 \times 273 \times 273 \times R}{1000 \Delta H_f}$
D. ΔT_b of solution contianin 3.0 g of urea in 50 g of water	s. $\dfrac{273 \times 273 \times R}{1000 L_f}$

Integer Type

17. The molal freezing point depression constant of benzene is 4.90 K kg mol^{-1}. Selenium exists as a polymer of the type Se$_x$. When 3.2 g of selenium is dissolved in 226 g of benzene, the observed freezing point is 0.112°C lower than pure benzene. What is x?

18. A solution of 6.2 g ethylene glycol in 55 g H_2O is cooled to −3.72°C. The ice separated from solution is : (K_f H_2O = 1.86 K molallity^{-1})

Comprehension Type

A solution of sucrose (molar mass = 342 g mol^{-1}) has been prepared by dissolving 68.4 g of sucrose in one kg of water. K_f for water is 1.86 K kg mol^{-1} and vapour pressure of water at 298 K is 0.024 atm.

19. The vapour pressure of the solution at 298 K will be
(a) 0.230 atm (b) 0.233 atm
(c) 0.236 atm (d) 0.0239 atm

20. The freezing point of the solution will be
(a) −0.684°C (b) −0.342°C
(c) −0.372°C (d) −0.186°C

Answers Key

Single Correct Answer Type

5. (a) **6.** (c) **7.** (c) **8.** (b) **9.** (a)
10. (a) **11.** (d)

Multiple Correct Answers Type

12. (a, d) **13.** (a, c, d) **14.** (b, c, d) **15.** (c, d)

Matching Column Type

16. (A → r, s), (B → p, q), (C → r, s), (D → p, q)

Integer Type

17. (8) **18.** (5)

Comprehension Type

19. (d) **20.** (c)

DPP 2.5

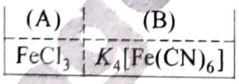
Osmotic Pressure

Subjective Type

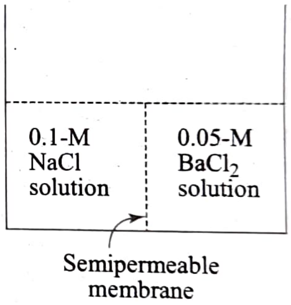
1. 2.5 g of a substance is present in 200 mL of solution showing the osmotic pressure of 60 cm Hg at 15°C. Calculate the molar mass of substance. What will be the osmotic pressure if temperature is raised to 25°C?
2. Calculate O.P. of a solution obtained by mixing 100 mL of 3.4% solution (mass/vol.) of urea (molar mass 60) and 100 mL of 1.6% solution (mass/vol.) of cane-sugar (molar mass 342) at 20°C.
3. How can you remove the hard calcium carbonate layer of the egg without damaging its semipermeable membrane? Can this egg be inserted into a bottle with a narrow neck without distorting its shape? Explain the process involved.
4. (i) Why an unripe mango placed in a concentrated salt solution to prepare pickel shrivels?
   (ii) The osmotic pressure of a solution of a synthetic polyisobutylene in benzene was determined at 25°C. A sample containing 0.20 g of solute/100 cm^3 of solution developed a rise of 2.4 mm at osmotic equilibrium. The density of the solution was 0.88 g/cm^3. What is the molecular weight of the polyisobutylene?

Single Correct Answer Type

5. Two solutions (A) containing $FeCl_3$ (aq) and (B) semipermeable membrane as shown below. If $FeCl_3$ on reaction with $K_4[Fe(CN)_6]$, produces blue colour of $Fe_4[Fe(CN)_6]$, the blue colour will be noticed in:



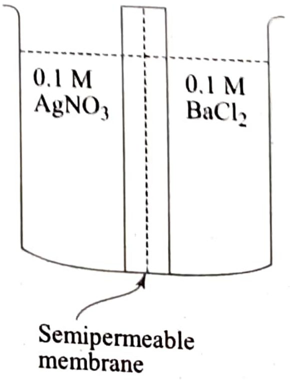
   (a) (A)
   (b) (B)
   (c) in both (A) and (B)
   (d) neither in (A) nor in (B)
6. The plots of osmotic π (in atm) *vs.* concentration (in g/cm^3) of a polymer at 300 K gives a straight line having slope 2×10^{-3}. The molar mass of polymer is:
   (a) 1.23×10^6 (b) 1.23×10^7
   (c) 4×10^7 (d) 4×10^6
7. Solute *A* is a ternary electrolyte and solute *B* is non-electrolyte. If 0.1 M solution of solute *B* produces an osmotic pressure of 2 P, then 0.05 M solution of *A* at the same temperature will produce an osmotic pressure equal to:
   (a) P (b) 1.5 P (c) 2 P (d) 3 P
8. Insulin $(C_2H_{10}O_5)_n$ is dissolved in a suitable solvent and the osmotic pressure (π) of solutions of various concentrations C (g/cm^3) is measured at 20°C. The slope of a plot of π against C is found to be 4.65×10^{-3}. The molar mass of the insulin is:
   (a) 4.8×10^5 (b) 9×10^5
   (c) 3×10^5 (d) 5.17×10^6
9. What is osmolarity of a 0.20 M KCl solution?
   (a) 0.10 osmol (b) 0.20 osmol
   (c) 0.30 osmol (d) 0.40 osmol
10. Study the following figure, and choose the correct options.



   (a) There will be no movement of any solution across the membrane
   (b) Solvent of $BaCl_2$ will flow towards the NaCl solution
   (c) NaCl will flow towards the $BaCl_2$ solution
   (d) The osmotic pressure of 0.1 MNaCl is higher than the osmotic pressure of 0.05 M $BaCl_2$, assuming complete dissociation of the electrolyte

Multiple Correct Answers Type

11. Study the figure given below and pick out the correct option(s) of the following:



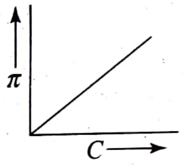
(a) A white precipitate of AgCl is formed on $AgNO_3$ side
(b) A white precipitate of AgCl is formed on $BaCl_2$ side
(c) No precipitate is formed on either side
(d) Meniscus of $BaCl_2$ solution rises and that of $AgNO_3$ solution falls in due course of time

12. In which of the following solutions, $Cu_2[Fe(CN)_6]$ permits the solvent molecules to pass through?
(a) Benzoic acid in benzene
(b) Urea in acetone
(c) Urea in water
(d) Thiourea in water

13. At what temperature(s) is/are correct about osmotic pressure (P), volume (V) and temperature (T)?
(a) $P \propto 1/V$ if T is constant
(b) $P \propto T$ if V is constant
(c) $P \propto V$ if T is constant
(d) PV is constant if T is constant

14. The slope of π *vs* C was made against insulin concentration (C) in g mL^{-1} and temperature 27°C. If C is in $litre^{-1}$ and the slope of line obtained is 4.65×10^{-3} g/mL, which of the following are not the molar mass (in g mol^{-1}) of insulin?
(a) 9×10^5 (b) 3×10^5
(c) 4.5×10^5 (d) 5.30×10^6

15. **A graph** showing variation of osmotic pressure (π) ***versus*** **molar** concentration (C) of an aqueous solution at temperature T is given below:



The slope of the line doesn't represent :
(a) solution constant R
(b) absolute temperature T
(c) RT
(d) degree of ionization of solute

Matching Column Type

16. Match the items given in Column I and Column II.

Column I	Column II
(i) Saturated solution	a. Solution having same osmotic pressure at a given temperature as that of given solution.
(ii) Binary solution	b. A solution whose osmotic pressure is less than that of another.
(iii) Isotonic solution	c. Solution with two components.
(iv) Hypotonic solution	d. A solution which contains maximum amount of solute that can be dissolved in a given amount of solvent at given temperature.
(v) Solid solution	e. A solution whose osmotic pressure is more than that of another.
(vi) Hypertonic solution	f. A solution in solid phase.

Integer Type

17. An aqueous solution of a substance molar mass 240 has osmotic pressure 0.2 atm at 300 K. The density of solution in g/dm^3 is : (R = 0.08 litre atm K^{-1} mol^{-1})

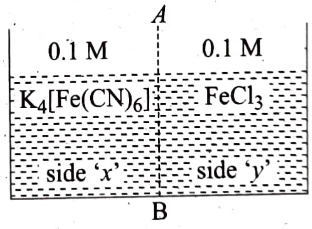
18. 18 g glucose and 6 g urea are dissolved in 1 L solution at 27°C. The osmotic pressure of the solution will be:

Comprehension Type

$FeCl_3$ on reaction with $K_4[Fe(CN)_6]$ in aqueous solution gives blue colour, according to the equation

$$4FeCl_3 + 3K_4[Fe(CN)_6] \rightarrow Fe_4[Fe(CN)_6]_3 + 12\ KCl$$

At 300 K two aqueous solution of $K_4[Fe(CN)_6]$ and $FeCl_3$ with equal concentrations 0.1 M. These two solutions are separated by a semi-permeable membrane AB as shown in figure.



19. What is true about the solutions?
(a) blue colour forms in side '*x*'
(b) blue colour forms in side '*y*'
(c) blue colour forms on both sides
(d) No blue colour formation

20. By applying external pressure osmosis can be stopped it should be applied to –
(a) side '*x*'
(b) side '*y*'
(c) equal on both the sides
(d) cannot be stopped by applying external pressure

Answers Key

Subjective Type

1. 374.38 g mol^{-1}, 62.08 **2.** 7.38 atm
4. (ii) 2.4×10^5 g/mol

Single Correct Answer Type

5. (d) **6.** (b) **7.** (d) **8.** (d) **9.** (d)
10. (b)

Multiple Correct Answers Type

11. (c, d) **12.** (c, d) **13.** (b, d) **14.** (a, b, c)
15. (a, b, d)

Matching Column Type

16. (i → d), (ii → c), (iii → a), (iv → b), (v → f), (vi → e)

Integer Type

17. (2) **18.** (5)

Comprehension Type

19. (d) **20.** (b)

DPP 2.6

Abnormal Molecular Mass and van't Hoff Factor

Subjective Type

1. Calculate the osmotic pressure of 20% (mass/vol.) anhydrous $CaCl_2$ solution at 0°C assuming 100% ionisation.
2. Under what conditions van't Hoff factor is
   (a) equal to unity (b) less than 1
   (c) greater than 1
   Explain your answer.
3. If the solution taken is too concentrated, then how it will affect the molar mass of the solution?
4. A dilute solution contains 'm' mol of solute A in 1 kg of a solvent with molal elevation constant K_b, the solute dimerises in solution as $2A \rightarrow A_2$. Show that equilibrium constant H for this dimer formation is $K = \frac{K_b(K_bm - \Delta T_b)}{(2\Delta T_b - K_bm)^2}$, where ΔT_b is the elevation in boiling point for the given solution.

Single Correct Answer Type

5. The van't Hoff factor i for a compound which undergoes dissociation in one solvent and association in other solvent is respectively:
   (a) greater than one and greater than one
   (b) less than one and greater than one
   (c) less than one and less than one
   (d) greater than one and less than one
6. The van't Hoff factor (i) for a dilute aqueous solution of Na_2SO_4 is:
   (a) $1 + \alpha$ (b) $1 - \alpha$
   (c) $1 + 2\alpha$ (d) $1 - 2\alpha$
7. The degree of dissociation (α) of a weak electrolyte, A_xB_y is related to van't Hoff factor (i) by the expression:
   (a) $\alpha = \frac{i-1}{(x+y-1)}$ (b) $\alpha = \frac{i-1}{x+y+1}$
   (c) $\alpha = \frac{x+y-1}{i-1}$ (d) $\alpha = \frac{x+y+1}{i-1}$
8. Pure benzene freezes at 5.3°C. A solution of 0.223 g of phenylacetic acid ($C_6H_5CH_2COOH$) in 4.4 g of benzene (K_f = 5.12 kg mol^{-1}) freezes at 4.47°C. From the observation, one can conclude that
   (a) phenylacetic acid exists as such in benzene
   (b) phenylacetic acid undergoes partial ionisation in benzene
   (c) phenylacetic acid undergoes complete ionisation in benzene
   (d) phenylacetic acid dimerises in benzene
9. Vapour density of $PCl_5(g)$ dissociating into $PCl_3(g)$ and $Cl_2(g)$ is 100. Hence, van't Hoff factor for the case $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ is
   (a) 1.85 (b) 3.70 (c) 1.085 (d) 1.0425
10. We have three aqueous solution of NaCl labeled as 'A', 'B' and 'C' with concentration 0.1 M, 0.01 M and 0.001 M, respectively. The value of van't Hoff factor for these solution will be in the order
    (a) $i_A < i_B < i_C$ (b) $i_A > i_B > i_C$
    (c) $i_A = i_B = i_C$ (d) $i_A < i_B > i_C$
11. A compound MX_2 has observed and normal molar masses 65.6 and 164 respectively. Calculate the apparent degree of ionization of MX_2.
    (a) 75% (b) 85%
    (c) 65% (d) 25%

Multiple Correct Answers Type

12. Which of the following statements are correct?
    (a) The increasing order of osmotic pressure of 0.1 M aqueous solution containing different electrolyte is as follows. 0.1 M Glucose < 0.1 M Sodium chloride < 0.1 M Magnesium chloride
    (b) Density of a solution is independent of temperature
    (c) Camphor has comparatively larger value of K_f as compared to other common solvents.
    (d) Limiting value of van't Hoff factor of $K_4Fe(CN)_6$ is 11.
13. Consider 0.1 M solutions of two solutes X and Y. The solute X behaves uni-univalent strong electrolyte while the solute Y dimerises completely in solution. Which of the following statements are correct regarding these solutions?
    (a) The solution of Y is hypotonic to that of X
    (b) Lowering of vapour pressure of solution of X is higher than that of Y

(c) The depression of freezing point of solution X is four times that of solution Y

(d) The escaping tendency of solvent into the vapour state from solution X is higher that from solution Y

14. For a 0.1 m solution, each of two solutes X and Y in which solute X behaves as a univalent electrolyte and Y dimerises in solution. The correct statement(s) are

(a) The b.p. of solution of solute X will be higher than that of Y.

(b) The osmotic pressure of the solution of solute Y will be lower than that of X.

(c) The freezing point of solution of solute X will be lower than that of Y.

(d) The relative lowering of V.P. of solution of solute X will be same as that of Y.

15. 1.2575 g sample of $[\text{Cr(NO}_3)\text{SO}_4 \cdot \text{Cl}]$ (molar mass 251.5 g mol^{-1}) is dissolved to prepare 250 mL solution showing an osmotic pressure of 1.478 atm of Hg are 27°C. Which are correct about this solution?

(a) Each molecule furnishes three ions in solution

(b) The van't Hoff factor is = 3

(c) Equilibrium molarity of $[\text{Cr(NH}_3)_6\text{SO}_4\text{Cl}] = 0$

(d) Equilibrium molarity of $[\text{Cr(NH}_3)_6{}^+]^{3+} = 0.02$ M

16. 2 litre of 1 molar solution of a complex salt $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ (molar mass 266.5 g mol^{-1}) shows an osmotic pressure of 98.52 atm. The solution is now treated with 1 litre of 6 M AgNO_3, which of the following are correct?

(a) Mass of AgCl precipitated is 861 g

(b) The clear solution will show an osmotic pressure = 98.52 atm

(c) The clear solution will show an osmotic pressure = 65.68 atm

(d) 2 mole of $[\text{Cr(H}_2\text{O)}_6]\ (\text{NO}_3)_3$ will be present in solution.

Matching Column Type

17. Match Column I with Column II:

Column I	Column II
a. $\text{K}_4[\text{Fe(CN)}_6]$	p. 1
b. $\text{Fe}_2\ (\text{SO}_4)_3$	q. $1 + 4\alpha$
c. $\text{C}_6\text{H}_{12}\text{O}_6$	r. $1 + \alpha$
d. BaCl_2	s. Greater than 1
	t. less than 1

Integer Type

18. A 1.17% solution of NaCl is isotonic with 7.2% solution of glucose. Calculate the van't Hoff factor of NaCl.

19. Calculate osmotic pressure of a decinormal solution of BaCl_2 at 27°C showing 70% degree of ionisation.

Comprehension Type

Colligative properties of a solution depend upon the number of moles of the solute dissolved and do not depend upon the nature of the solute. However, they are applicable only to dilute solutions in which the solutes do not undergo any association or dissociation. For solutes undergoing such changes, van't Hoff introduced a factor, called van't Hoff factor (i). This has helped not only to explain the abnormal molecular masses of such solutes in the solution but has also helped to calculate the degree of association or dissociation.

20. The van't Hoff factor for 0.1 M $\text{Ba(NO}_3)_2$ solution is 2.74. The degree of dissociation is

(a) 91.3% (b) 87% (c) 100% (d) 74%

21. Which one of the following aqueous solutions will have the lowest freezing point?

(a) 0.1 molal solution of urea

(b) 0.1 molal solution of acetic acid

(c) 0.1 molal solution of sodium chloride

(d) 0.1 molal solution of calcium chloride

Answers Key

Single Correct Answer Type

5. (d) **6.** (c) **7.** (a) **8.** (d) **9.** (d)
10. (b) **11.** (a)

Multiple Correct Answers Type

12. (a, c) **13.** (a, b, c) **14.** (a, b, c)
15. (a, b, c, d) **16.** (a, c, d)

Matching Column Type

17. (a → q, s), (b → q, s), (c → p), (d → s)

Integer Type

18. (2) **19.** (3)

Comprehension Type

20. (b) **21.** (d)

CHAPTER 3

Electrochemistry

DPP 3.1

Electrolytic Conduction

Subjective Type

1. Why is alternating current used for measuring resistance of an electrolytic solution?
2. Solutions of two electrolytes A and B are diluted. The Λ_m of 'B' increases 1.5 times while that of A increases 25 times. Which of the two is a strong electrolyte? Justify your answer.
3. Why on dilution the Λ_m of CH_3COOH increases drastically, while that of CH_3COONa increases gradually?
4. A 100 watt, 110 volt incandescent lamp is connected in series with an electrolytic cell containing cadmium sulphate solution. What mass of cadmium will be deposited by the flowing for 10 hours?
5. The resistance of a solution 'A' is 50 ohm and that of solution 'B' is 100 ohm, both solutions being taken in the same conductivity cell. If equal volumes of solutions A and B are mixed, what will be the resistance of the mixture using the same cell? (Assume that there is no increase in the degree of dissociation of A and B on mixing).
6. The equivalent conductivity of acetic acid at infinite dilution is 387 S cm^2 eq^{-1}. At the same temperature, 0.001 M solution of acetic acid, it is 55 S cm^2 eq^{-1}. What is the degree of dissociation of 0.1 N acetic acid? Assume $1-\alpha \approx 1$.
7. Calculate the dissociation constant of water at 25°C from the following data:
   Conductivity of $H_2O = 5.8 \times 10^{-8}$ S cm^{-1}, $\lambda^{o}_{H^+} = 350.0$ and $\lambda^{o}_{OH^-} = 198.0\ \text{S cm}^2\ \text{eq.}^{-1}$.

Single Correct Answer Type

8. A conductance cell when filled with 0.5 M KCl solution (conductivity $= 6.67 \times 10^{-3}\ \Omega^{-1}\ \text{cm}^{-1}$) registers a resistance of 243 Ω. Its cell constant is
   (a) 1.62 cm (b) 1.62 cm^{-1}
   (c) 1.62 dm^{-1} (d) 1.62 m^{-1}
9. The equilibrium constant of acetic acid in an aqueous solution of concentration c is given by
   (a) $K = \dfrac{c\Lambda_c^2}{\Lambda^\infty - \Lambda_c}$ (b) $K = \dfrac{c\Lambda_c^2}{\Lambda^\infty(\Lambda^\infty - \Lambda_c)}$
   (c) $K = \dfrac{c\Lambda_c^2}{\Lambda^\infty + \Lambda_c}$ (d) $K = \dfrac{c\Lambda_c}{\Lambda^\infty(\Lambda^\infty - \Lambda_c)}$
10. The molar conductivity of 0.05 M of solution of an electrolyte is 200 Ω^{-1} cm^2 mol^{-1}. The resistance offered by a conductivity cell with cell constant (1/3) cm^{-1} would be about
    (a) 11.11 Ω (b) 22.22 Ω
    (c) 33.33 Ω (d) 44.44 Ω
11. If $\lambda^\infty_m(K^+) = 73.5\ \Omega^{-1}\ \text{cm}^2\ \text{mol}^{-1}$, $\lambda^\infty_m(Al^{3+}) = 189\ \Omega^{-1}\ \text{cm}^2\ \text{mol}^{-1}$ and $\lambda^\infty_m(SO_4^{2-}) = 160\ \Omega^{-1}\ \text{cm}^2\ \text{mol}^{-1}$, the molar conductivity of potash alum will be about
    (a) 1165 Ω^{-1} cm^2 mol^{-1}
    (b) 422.5 Ω^{-1} cm^2 mol^{-1}
    (c) 582.5 Ω^{-1} cm^2 mol^{-1}
    (d) 145.6 Ω^{-1} cm^2 mol^{-1}

12. The molar conductivity of a weak electrolyte HA at infinite dilution can be determined by

(a) extrapolating Λ_m versus c plot to $c \to 0$.

(b) extrapolating Λ_m versus $\sqrt{c}$ plot to $c \to \infty$.

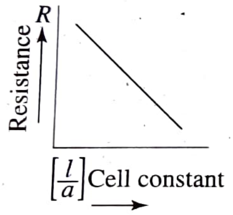
(c) using Kohlrausch law with the data on Λ_m^∞(HCl), Λ_m^∞(NaA) and Λ_m^∞(NaCl)

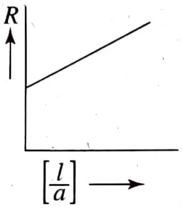
(d) using Kohlraush law with the data on Λ_m^∞(HA) and Λ_m^∞(NaA).

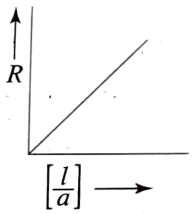
13. When a certain conductivity cell was filled with 0.01 M solution of KCl, it had a resistance of 160 Ω at 25°C, and when filled with 0.005 M NaOH, it had a resistance of 190 Ω. If specific resistance of KCl solution is 700 Ω-cm, specific conductance (Ω^{-1} cm^{-1}) solution is

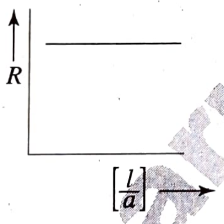
(a) 0.00120 (b) 0.00170
(c) 0.00180 (d) 0.00190

14. Variation of resistance with increase in cell constant gives graph of the type

(a)


(b)


(c)


(d)


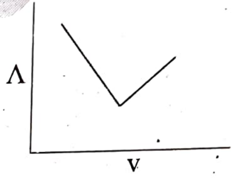
15. The molar conductivity of $LiNO_3$ at infinite dilution is 10^5 S cm^2 mol^{-1}. If 0.02 M solution shows conductance of 0.158 ohm^{-1} using cell of cell constant 1 cm^{-1}. The concentration of Li^+ ion in g $litre^{-1}$ is:

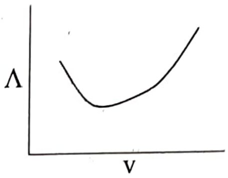
(a) 0.01106 (b) 0.1106
(c) 11.06 (d) 0.2212

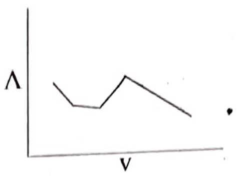
16. The absolute velocity of Ag^+ and NO_3^- are 5.7 × 10^{-4} cm sec^{-1} and 6.9 × 10^{-4} cm sec^{-1} respectively. Assuming complete dissociation of $AgNO_3$, calculate the molar conductivity of $AgNO_3$ at infinite dilution.

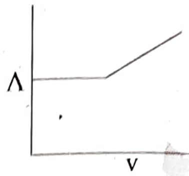
(a) 121.59 S cm^2 mol^{-1} (b) 141.59 S cm^2 mol^{-1}
(c) 131.59 S cm^2 mol^{-1} (d) none of these

17. $AgNO_{3(aq)}$ was added to an aqueous KCl solution gradually and the conductivity of the solution was measured. The plots of conductance Λ *vs* volume of $AgNO_3$ (aq) is:

(a)


(b)


(c)


(d)


Multiple Correct Answers Type

18. Which one is a correct statement?

(a) Conductance is an additive property

(b) Conductance order: $Li^+_{(aq.)} < Na^+_{(aq.)} < K^+_{(aq.)} < Rb^+_{(aq.)}$

(c) Molar conductivity of NH_4^+ in liquid NH_3 is highe than in H_2O

(d) At infinite dilution all the interionic attractio vanishes

19. An ion travels 0.4 cm in 1 minute under the influence 2 volt potential difference when electrodes are 3 cm apa Which one are correct?

(a) Speed of ion = 6.67 × 10^{-3} cm s^{-1}

(b) Ionic mobility = 1 × 10^{-6} m^2 $volt^{-1}$ sec^{-1}

(c) Ionic mobility = 1.0 × 10^{-3} cm^2 $volt^{-1}$ sec^{-1}

(d) Ionic mobility = 4.44 × 10^{-3} cm^2 $volt^{-1}$ sec^{-1}

20. Which ion(s) has/have exceptionally higher λ^∞ values?

(a) H^+ (b) K^+
(c) OH^- (d) NH_2^-

21. For which, the formula $\alpha = \frac{\lambda_v}{\lambda_\infty}$ does not hold good?

(a) CH_3COOH (b) HCl
(c) $HClO_4$ (d) CH_3NH_2

22. The factor(s) which influence(s) the conductance solutions is.

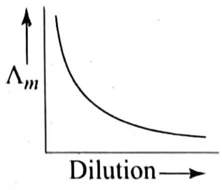
(a) Solute-solute interaction

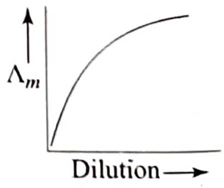
(b) Solute-solvent interaction

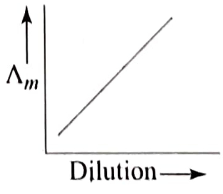
(c) Temperature

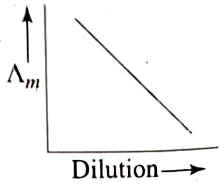
(d) Solvent-solvent interaction

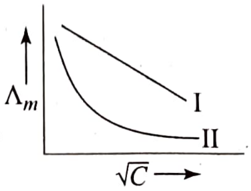
23. Which of the following graph incorrectly represents variation of molar conductance (Λ_m) with dilution fo strong electrolyte?

(a)


(b)


(c)


(d)


24.


Above plot represents the variation of molar conductance against $\sqrt{C}$ (where C = molar concentration of the electrolyte). Select the incorrect options among the following:

(a) Both I and II are for strong electrolyte
(b) Both I and II are for weak electrolyte
(c) I is for strong electrolyte and II for weak electrolyte
(d) I is for weak electrolyte and II for strong electrolyte

Matching Column Type

25. Match the physical term in Column I with the unit in Column II.

	Column I		Column II
(a)	Conductance	(p)	siemen m^2 mol^{-1}
(b)	Resistivity	(q)	m^{-1}
(c)	Conductivity	(r)	volt per ampere
(d)	Molar conductivity	(s)	siemen
(e)	Cell constant	(t)	siemen m^{-1}
(f)	Resistance	(u)	ohm metre

Integer Type

26. The molar conductivity of acetic acid at infinite dilution is 390.7 and for 0.01 M acetic acid is 3.907 S cm^2 mol^{-1}. What is the pH solution?

27. The specific conductivity of N/50 solution of KCl at 298 K is 0.002501 S cm^{-1}. If the resistance of the same solution placed in the cell is 2000 ohms, what is the cell constant?

Comprehension Type

The molar conductance of NaCl varies with the concentration as shown in the following table:

Molar concentration of NaCl	Molar conductance in ohm^{-1} cm^2 mol^{-1}
4×10^{-4}	107
9×10^{-4}	97
16×10^{-4}	87

When a certain conductivity cell (C) was filled with 25×10^{-4}(M) NaCl solution, the resistance of the cell was found to be 1000 ohm. At infinite dilution ion conductances of Cl^- and SO_4^{2-} are 80 ohm^{-1} cm^2 mol^{-1} and 160 ohm^{-1} cm^2 mol^{-1} respectively.

28. What is the molar conductance of NaCl at infinite dilution?

(a) 147 ohm^{-1} cm^2 mol^{-1}
(b) 107 ohm^{-1} cm^2 mol^{-1}
(c) 127 ohm^{-1} cm^2 mol^{-1}
(d) 157 ohm^{-1} cm^2 mol^{-1}

29. What is the cell constant of the conductivity cell(C)?

(a) 0.385 cm^{-1} (b) 3.85 cm^{-1}
(c) 38.5 cm^{-1} (d) 0.1925 cm^{-1}

30. If the cell(C) is filled with 5×10^{-3} (N) Na_2SO_4, the observed resistance was 400 ohm. What is the molar conductance of Na_2SO_4?

(a) 19.25 ohm^{-1} cm^2 mol^{-1}
(b) 96.25 ohm^{-1} cm^2 mol^{-1}
(c) 385 ohm^{-1} cm^2 mol^{-1}
(d) 192.4 ohm^{-1} cm^2 mol^{-1}

Answers Key

Subjective Type

4. 19.06 g **5.** 66.67 ohm
6. 1.5% **7.** 2×10^{-16} mol/litre

Single Correct Answer Type

8. (b) **9.** (b) **10.** (c) **11.** (a) **12.** (c)
13. (a) **14.** (c) **15.** (a) **16.** (a) **17.** (d)

Multiple Correct Answers Type

18. (a, b, c, d) **19.** (a, b) **20.** (a, c)
21. (b, c) **22.** (a, b, c, d) **23.** (a, c, d)
24. (a, b, d)

Matching Column Type

25. (a → s), (b → u), (c → t), (d → p), (e → q), (f → r)

Integer Type

26. (4) **27.** (5)

Comprehension Type

28. (c) **29.** (d) **30.** (d)

DPP 3.2

Electrolysis and Faraday's Laws

Subjective Type

1. An aqueous solution of copper sulphate is electrolysed using platinum electrodes in one case and copper electrodes in another case. Will the products of electrolysis be same or different? Give reason.

2. State the products of electrolysis obtained on the cathode and the anode in the following cases:
   (i) A dilute solution of H_2SO_4 with platinum electrodes.
   (ii) An aqueous solution of $AgNO_3$ with silver electrodes.

3. A current of 2 ampere is passed for one hour between nickel electrodes in 0.5 L of 2 M $Ni(NO_3)_2$ solution. What will be the molarity of the solution at the end of electrolysis?

4. (i) On electrolysis of an aqueous solution NaCl, why H_2 and not Na is liberated at the cathode?
   (ii) One faraday of electricity deposits one mole of Na from the molten salt but $\frac{1}{3}$ mol of Al from an aluminium salt. Why?

Single Correct Answer Type

5. In electrolysis of an aqueous solution of sodium sulphate, 2.4 L of oxygen at STP was liberated at anode. The volume of hydrogen at STP liberated at cathode would be:
(a) 1.2 L
(b) 2.4 L
(c) 2.6 L
(d) 4.8 L

6. What mass of silver could be plated out on a serving tray by electrolysis of a solution containing silver in +1 oxidation state for a period of 8 hours at a current of 8.46 amperes? What is the area of tray if the thickness of the silver plating is 0.00254 cm? Density of silver is 10.5 g/cm^3.
(a) 11200 cm^2
(b) 10204.7 cm^2
(c) 10300 cm^2
(d) 9237.4 cm^2

7. A certain electricity deposited 0.54 g of Ag from $AgNO_3$ solution. What volume of hydrogen will the same quantity of electricity liberate at 27°C and 728 mm Hg pressure?
(a) 62.48 mL
(b) 60.00 mL
(c) 64.28 mL
(d) 66.5 mL

8. The time taken to decompose electrolytically 18 g water by 2 A current is about
(a) 24.8 h
(b) 26.8 h
(c) 28.8 h
(d) 30.8 h

9. Which of the following gives the charge of an electron?
(a) $1\ F/1\ N_A$
(b) 1 F
(c) $1\ F \times 1\ N_A$
(d) $1\ N_A/1\ F$

10. In the electrolysis of copper(II) chloride solution, the mass of cathode is increased by 3.15 g. At copper anode, we will have
(a) the liberation of 1120 mL of Cl_2 at STP
(b) the liberation of 560 mL of O_2 at STP
(c) the loss of 3.15 g of Cu
(d) the gain of 3.15 g of Cu

11. One g equivalent of Na metal is formed from electrolysis of fused NaCl. No. of moles of Al from the fused Na_3AlF_6 with the same current passed is:
(a) 1
(b) 3
(c) 1/3
(d) 2

Multiple Correct Answers Type

12. Which of the following statements are correct?
(a) Sodium can be obtained by the electrolysis of aqueous solution of NaCl using Pt electrodes.
(b) The current carrying ions in an electrolytic cell are not necessarily discharged at the electrodes.
(c) The mass of a substance deposited on the cathode or anode during electrolysis is given as $m = QM/F\,|v_e|$
(d) In the purification of a metal by electrolytic method the impure metal is made cathode.

13. Which of the following statements are not correct?
(a) The reaction involving reduction of water is $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$
(b) The species having a least reduction potential is preferentially reduced at the cathode.
(c) Water is reduced in preference to the cations having more positive potential than –0.828 V.
(d) In the electrolysis of a solution containing SO_4^{2-} anion only, the anodic reaction is $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

14. Which of the following statements are not correct?
(a) The electrolysis of a solution containing Cl^- anion produces Cl_2 at anode but O_2 is also liberated as the solution is diluted.
(b) The quantitative relationship between electricity and chemical change were established by Faraday.
(c) When an aqueous solution of sodium fluoride is electrolysed, the gas liberated at the anode is F_2.
(d) In an electrolytic refining of an impure metal, the pure metal is obtained at anode.

15. Three moles of electrons are passed through three solutions in succession containing $AgNO_3$, $CuSO_4$ and $AuCl_3$, respectively. The molar ratio of amounts of cations reduced at cathode will be

(a) 1 : 2 : 3 (b) $\frac{1}{1}:\frac{1}{2}:\frac{1}{3}$

(c) 3 : 2 : 1 (d) 6 : 3 : 2

16. On electrolysis, in which of the following, O_2 would be liberated at the anode?

(a) dilute H_2SO_4 with Pt electrodes

(b) aqueous $AgNO_3$ solution with Pt electrodes

(c) dilute H_2SO_4 with Cu electrodes

(d) aqueous NaOH with a Fe cathode and a Pt anode

Matching Column Type

17. Match the Column I with Column II:

	Column I (Electrolysis)		Column II (pH and products at anode and cathode)
(a)	Electrolysis of 100 L aqueous solution CH_3COOK by passing 2 F of electricity	(p)	pH = 12.3 Anode = Ethane(g) + CO_2(g) Cathode = H_2(g)
(b)	Electrolysis of 10 L aqueous solution HCOOK by passing 1 F of electricity	(q)	pH = 13.0 Anode = H_2(g) + CO_2(g) Cathode = H_2(g)
(c)	Electrolysis of 10 L aqueous solution K_2SO_4 by passing 1 F of electricity	(r)	pH = 7.0 Anode = O_2(g) Cathode = H_2(g)
(d)	Electrolysis of 10 L aqueous solution CuF_2 by passing 1 F of electricity	(s)	pH = 1.0 Anode = O_2(g) Cathode = Cu(g)

Integer Type

18. How many grams of Cl_2(g) can be produced by the electrolysis of molten NaCl with a current of 5.5 A for 25 min? [Atomic weight of Cl = 35.5 amu]

19. A current strength of 96.5 A is passed for 10 sec through 1 L of solution of 0.1 M aqueous $CuSO_4$, calculate the pH of the solution.

Comprehension Type

Electrolysis is the process in which electrical energy is converted to chemical energy. In electrolytic cell, oxidation takes place at anode and reduction at cathode. Electrode process depends on the electrode taken for electrolysis. Amount of substance liberated at an electrode is directly proportional to the amount of charge passed through it. The mass of substance liberated at electrode is calculated using the following relation:

$$m = \frac{ItE}{96500}$$

Here, E represents the equivalent mass and 96500 C is called the Faraday constant. Faraday (96500 C) is the charge of 1 mol electron, i.e., 6.023×10^{23} electrons; it is used to liberate one gram equivalent of the substance.

20. The platinum electrodes were immersed in a solution of cupric sulphate ($CuSO_4$) and electric current is passed through the solution. After sometime, it was observed that the colour of copper sulphate disappeared with evolution of a gas at the electrode. The colourless solution contains:

(a) platinum sulphate (b) copper nitrate

(c) copper sulphate (d) sulphuric acid

21. The passage of current librates H_2 at cathode and Cl_2 at anode. The solution is:

(a) copper chloride in water

(b) NaCl in water

(c) mercuric chloride in water

(d) $AuCl_3$ in water

22. On electrolysis of dilute sulphuric acid using platinum electrodes, the product obtained at the anode will be:

(a) hydrogen (b) oxygen

(c) hydrogen sulphite (d) sulphur oxide

23. How many faradays are required to reduce 1 mol BrO_3^- to Br^-?

(a) 3 (b) 5 (c) 6 (d) 4

24. Calculate the volume of gas liberated at the anode at S.T.P. during the electrolysis of a $CuSO_4$ solution by a current of 1 A passed for 16 min and 5 sec.

(a) 224 mL (b) 56 mL

(c) 112 mL (d) 448 mL

Answers Key

Single Correct Answer Type

5. (d) **6.** (b) **7.** (c) **8.** (b) **9.** (a)

10. (c) **11.** (c)

Multiple Correct Answers Type

12. (a, d) **13.** (b, c, d) **14.** (c, d)

15. (b, d) **16.** (a, b, d)

Matching Column Type

17. (a → p), (b → q), (c → r), (d → s)

Integer Type

18. (3) **19.** (2)

Comprehension Type

20. (d) **21.** (b) **22.** (b) **23.** (c) **24.** (b)

Cengage Learning Pvt. Ltd.

DPP 3.3

Fuel Cell and Batteries

Subjective Type

1. (i) What advantage do the fuel cells have over primary and secondary batteries?
   (ii) Write the cell reaction of a lead storage battery when it is discharged. How does the density of the electrolyte change when the battery is discharged?
2. (i) What is the role of $ZnCl_2$ in a dry cell?
   (ii) Why a mercury cell gives a constant voltage throughout its life?
3. Which type of cells are rechargeable?
4. During the discharge of a lead storage battery, density of H_2SO_4 fell from 1.294 g/mL to 1.139 g/mL. Sulphuric acid of density 1.294 g/mL is 39% H_2SO_4 by weight and that of density 1.139 g/mL is 20% H_2SO_4 by weight. The battery holes 3.5 litres of the acid and volume remains practically constant during discharge. Calculate ampere-hour of which the battery must have been used. The charging and discharging reactions are:

$$Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^- \quad \text{(charging)}$$

$$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O \quad \text{(discharging)}$$

5. In a fuel cell H_2 and O_2 react to produce electricity. In the process H_2 gas is oxidised at the anode and O_2 is reduced at the cathode. If 67.2 litres of H_2 at NTP reacts in 15 minute, what is the average current produced? If the entire current is used for electro-deposition of Cu from Cu^{2+}, how many g of Cu are deposited?

Single Correct Answer Type

6. When a lead storage battery is discharged, then:
   (a) SO_2 is evolved
   (b) lead is formed
   (c) lead sulphate is consumed
   (d) sulphuric acid is consumed
7. A depolarizer used in dry cell batteries is:
   (a) ammonium chloride (b) manganese dioxide
   (c) potassium hydroxide (d) sodium phosphate
8. An example of a simple fuel cell is:
   (a) lead storage battery (b) $H_2 - O_2$ cell
   (c) Daniell cell (d) Leclanche cell
9. Which of the following reactions occurs at cathode during charging of storage battery?
   (a) $Pb^{2+} + 2e^- \rightarrow Pb$
   (b) $Pb \rightarrow Pb^{2+} + 2e^-$
   (c) $Pb^{2+} + SO_4^{2-} \rightarrow PbSO_4$
   (d) $PbSO_4 + 2H_2O \rightarrow PbO_2 + 4H^+ + SO_4^{2-} + 2e^-$
10. Hydrogen–oxygen fuel cells are used in spacecraft to supply:
    (a) power for heat and light
    (b) power for pressure
    (c) oxygen
    (d) none of these
11. In a H_2–O_2 cell, combustion of hydrogen occurs due to:
    (a) remove adsorbed oxygen from electrode surface
    (b) create potential difference between the two electrodes
    (c) produce high purity water
    (d) generate heat

Multiple Correct Answers Type

12. Which is/are correct about fuel cells?
    (a) Cells continuously run as long as fuels are supplied
    (b) These are more efficient and free from pollution
    (c) These are used to provide power and drinking water to astronauts in space programme
    (d) None of these
13. During the discharge of lead storage battery:
    (a) PbO_2 is reduced
    (b) Pb is oxidised
    (c) specific gravity of H_2SO_4 gives extent of discharging
    (d) equivalent mass of H_2SO_4 is 98
14. Which of the following statements are correct about Ni-Cd cell
    (a) It consists of a cadmium electrode (as anode) and a metal grid containing nickel (IV) oxide (as cathode) immersed in KOH solution.
    (b) At cathode: $NiO_2(s) + 2H_2O + 2e^- \rightleftharpoons Ni(OH)_2(s) + 2OH^-(aq)$
    (c) At anode: $Cd(s) + 2OH^-(aq) \rightleftharpoons Cd(OH)_2(s) + 2e^-$
    (d) The potential of each Ni-Cd cell is approximately 2.6 V.
15. During the charging of lead storage battery, which reactions don't occur at anode are:
    (a) $Pb^{2+} + SO_4^{2-} \rightarrow PbSO_4$
    (b) $PbSO_4 + H_2O \rightarrow PbO_2 + SO_4^{2-} + 2H^+$

(c) $Pb \rightarrow Pb^{2+} + 2e$
(d) $Pb^{2+} + 2e \rightarrow Pb$

16. Fuel cell involves following reaction(s):
(a) $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq.)$ (at cathode)
(b) $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq.)$ (at anode)
(c) $2H_2(g) + 4OH^-(aq) \rightarrow 4H_2O(l) + 4e^-$ (at anode)
(d) $2H_2(g) + 4OH^-(aq) \rightarrow 4H_2O(l) + 4e^-$ (at cathode)

Matching Column Type

17. Match the following:

Column I		Column II	
(a)	Leclanche cell	(p)	Cell reaction $2H_2 + O_2 \rightarrow 2H_2O$
(b)	Ni-Cd cell	(q)	Does not involve any ion in solution and is used in hearing aids.
(c)	Fuel cell	(r)	Rechargeable
(d)	Mercury cell	(s)	Reaction at anode, $Zn \rightarrow Zn^{2+} + 2e^-$

Integer Type

18. The emf of lead storage battery is …… V.

Comprehension Type

A lead storage battery consists of a lead anode and a grid of lead packed with lead dioxide as the cathode. The electrolyte taken is 39% H_2SO_4 by mass having a density of 1.294 g mL^{-1}. The battery holds 3.5 L of the acid. During the discharge of the battery, the density H_2SO_4 falls from 1.294 g mL^{-1} to 1.139 g mL^{-1} which is 20% H_2SO_4 by mass.

19. The reaction occurring at the anode during charging is
(a) $Pb^{2+} + 2e^- \rightarrow Pb$
(b) $Pb^{2+} + SO_4^{2-} \rightarrow PbSO_4$
(c) $Pb \rightarrow Pb^{2+} + 2e^-$
(d) $PbSO_4 + 2H_2O \rightarrow 2PbO_2 + 4H^+ + SO_2^{2-} + 2e^-$

20. Moles of sulphuric acid lost during discharge is
(a) 9.88 (b) 8.88
(c) 7.88 (d) 6.88

21. Molarity of the solution after the discharge is
(a) 8.136 (b) 4.068
(c) 2.32 (d) 1.16

22. The amount of charge in colulombs used up by the battery is nearly
(a) 954180 (b) 477090
(c) 95418 (d) 47709

23. The number of ampere-hour for which the battery must have been used is
(a) 2650.5 (b) 265.05
(c) 26.505 (d) 2.6505

Answers Key

Subjective Type

4. 265.04 **5.** 643.3 amp, 190.5 g

Single Correct Answer Type

6. (d) **7.** (b) **8.** (b) **9.** (a) **10.** (a)
11. (b)

Multiple Correct Answers Type

12. (a, b, c) **13.** (a, b, c, d)
14. (a, b, c) **15.** (a, c, d)
16. (a, c)

Matching Column Type

17. (a → s), (b → r), (c → p), (d → q)

Integer Type

18. (2 V)

Comprehension Type

19. (d) **20.** (a) **21.** (c) **22.** (a) **23.** (b)

DPP 3.4

Construction and Working of a Cell, Electrochemical Series and Its Applications

Subjective Type

1. Predict whether zinc and silver react with 1 M sulphuric acid to give out hydrogen gas or not. Given that the standard reduction potentials of zinc and silver are – 0.76 volt and 0.80 volt respectively.

2. Iodine (I_2) and bromine (Br_2) are added to a solution containing iodide (I^-) and bromide (Br^-) ions. What reaction would occur if the concentration of each species is 1 M? The electrode potentials for the reactions are:

$E^\circ_{I_2/I^-} = 0.54$ V, $E^\circ_{Br_2/Br^-} = 1.08$ V

3. (i) Which of the following oxides is reduced by hydrogen?
MgO, CuO and Na_2O

(ii) Which of the following oxides will decompose on heating?
ZnO, CuO, MgO and Ag_2O

(iii) The value of E°_{ox} for electrode reactions, $Fe \rightarrow Fe^{2+} + 2e^-$, $Cu \rightarrow Cu^{2+} + 2e^-$, and $Zn \rightarrow Zn^{2+} + 2e^-$ are 0.444, –0.337 and 0.763 volts respectively. State which of these metals can replace the other two from the solution of their salts?

4. Determine range of E° values for this reaction

$$X^{2+}_{aq} + 2e^- \rightarrow X(s)$$ for given conditions:

(a) If the metal X dissolves in HNO_3 but not in HCl it can displace Ag^+ ion but not Cu^{2+} ion.

(b) If the metal X is HCl acid producing $H_2(g)$ but does not displace either Zn^{2+} or Fe^{2+}.
Given:

$E^\circ_{Ag^+/Ag} = 0.8$ V, $E^\circ_{Fe^{2+}/Fe} = -0.44$ V, $E^\circ_{Cu^{2+}/Cu} = 0.34$ V,

$E^\circ_{NO_3^-/NO} = 0.96$ V, $E^\circ_{Zn^{2+}/Zn} = -0.76$ V

Single Correct Answer Type

5. The standard potential at 298 K for the following half reactions are given against each:

$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	–0.762 V
$2H^+(aq) + 2e^- \rightleftharpoons Cr(s)$	0.000 V
$Cr^{3+}(aq) + 3e^- \rightleftharpoons Cr(s)$	–0.740 V
$Fe^{3+}(aq) + 2e^- \rightleftharpoons Fe^{2+}(aq)$	0.770 V

Which is the strongest reducing agent?
(a) Zn(s)
(b) Cr(s)
(c) $H_2(g)$
(d) $Fe^{2+}(aq)$

6. The following facts are available:

$2X^- + Y_2 \rightarrow 2Y^- + X_2$;
$2W^- + Y_2 \rightarrow$ No reaction;
$2Z^- + X_2 \rightarrow 2X^- + Z_2$

Which of the following statements is correct?

(a) $E^\circ_{W^-/W_2} > E^\circ_{Y^-/Y_2} > E^\circ_{X^-/X_2} > E^\circ_{Z^-/Z_2}$

(b) $E^\circ_{W^-/W_2} < E^\circ_{Y^-/Y_2} < E^\circ_{X^-/X_2} < E^\circ_{Z^-/Z_2}$

(c) $E^\circ_{W^-/W_2} < E^\circ_{Y^-/Y_2} > E^\circ_{X^-/X_2} > E^\circ_{Z^-/Z_2}$

(d) $E^\circ_{W^-/W_2} > E^\circ_{Y^-/Y_2} < E^\circ_{X^-/X_2} < E^\circ_{Z^-/Z_2}$

7. A gas X at 1 atm is bubbled through a solution containin a mixture of 1 M Y and 1 M Z at 25° C. If the reductio potential of Z > Y > X, then
(a) Y will oxidise X and not Z
(b) Y will oxidise Z and not X
(c) Y will oxidise both X and Z
(d) Y will reduce both X and Z

8. A large quantity of cobalt metal was dropped into a solutio containing Ag^+, Fe^{3+} and Cu^{2+}, all at unit concentration. I $E^\circ(Ag^+/Ag) = 0.799$ V, $E^\circ(Fe^{3+}, Fe^{2+}/Pt) = 0.77$ V, $E^\circ(Cu^{2}$ Cu) = 0.34 V, $E^\circ(Fe^{3+}/Fe) = -0.04$ V, $E^\circ(Cu^{2+}, Cu^+/Pt)$ 0.153 V and $E^\circ(Co^{2+}/Co) = 0.28$ V, then the solution woul contain
(a) Ag, Fe and Cu
(b) Ag, Fe and Cu^+
(c) Fe^{2+}, Cu and Co^{2+}
(d) Fe^{2+}, Cu, Ag and Co^{2+}

9. Given : $E^\circ(Sn^{2+}, Sn^{4+}/Pt) = 0.15$ V, $E^\circ(Hg_2^{2+}, Hg^{2+}/Pt)$ 0.92 V and $E^\circ(Pb^{2+}, H^+/PbO_2) = 1.45$ V. Based on this dat which of the following statements is correct?
(a) Sn^{4+} is a stronger oxidizing agent than Pb^{4+}
(b) Sn^{2+} is a stronger reducing agent than Hg_2^{2+}
(c) Hg^{2+} is a stronger oxidizing agent than Pb^{4+}
(d) Pb^{2+} is a stronger reducing agent than Sn^{2+}

10. Given below are some standard reduction potentials:

$Sn^{2+} + 2e^- = -0.14$ V $Hg_2^{2+} + 2e^- = 2Hg$ $E^\circ = 0.79$

Which of the following statements is correct?

(a) Hg can reduce Sn^{2+} to Sn

(b) Sn^{2+} can oxidize Hg to Hg_2^{2+}

(c) Hg_2^{2+} can oxidize Sn to Sn^{2+}

(d) Between Hg_2^{2+} and Sn^{2+}, Sn^{2+} is stronger oxidising agent than Hg_2^{2+}.

11. Given that E° values of Ag^+/Ag, K^+/K, Mg^+/Mg and Cr^{3+}/Cr are 0.80 V, – 2.90 V, –2.37 V, and –0.74 V, respectively. Which of the following orders regarding the reducing power of metals is correct?

(a) $Ag > Cr > Mg > K$
(b) $Ag < Cr < Mg < K$
(c) $Ag > Cr > K > Mg$
(d) $Cr > Ag > Mg > K$

12. Indicator electrode is:

(a) SHE
(b) Calomel electrode
(c) Ag/AgCl electrode
(d) Quinhydrone electrode

13. When an aqueous solution of lithium chloride is electrolysed using graphite electrodes:

(a) pH of the resulting solution increases
(b) pH of the resulting solution decreases
(c) as the current flows, pH of the solution around the cathode increases
(d) none of the above

14. The calomel electrode is reversible with respect to:

(a) Hg_2^{2+}
(b) H^+
(c) Hg^{2+}
(d) Cl^-

Multiple Correct Answers Type

15. Which of the following is/are true for standard hydrogen electrode?

(a) Temperature is maintained at 25°C
(b) Hydrogen ion concentration is 1 M
(c) Pressure of hydrogen gas is maintained at 1 atmosphere
(d) It contains platinum metal which is used to adsorb hydrogen gas.

16. The electrode potential of a glass electrode does not depend upon:

(a) concentration of chloride ions
(b) concentration of hydrogen ions
(c) concentration of KCl solution
(d) all of these

17. A KI solution containing starch, turns blue on the addition of chlorine. Which of the following statements explain(s) this?

(a) The standard reduction potential of Cl_2 is more than that of I_2
(b) The standard oxidation potential of Cl_2 is more than that of I_2
(c) The product formed when Cl_2 combines with starch is blue in colour
(d) The product formed when I_2 combines with starch is blue in colour

18. Which of the following statements is/are correct?

(a) A metal in its highest oxidation state acts as an oxidant
(b) In the reaction, $F_2 + \frac{1}{2}O_2 \longrightarrow OF_2$, oxygen is an oxidant
(c) The oxidant number of Ni in $Ni(CO)_4$ is zero
(d) Copper metal can be oxidized by Zn^{2+} ions

19. In which of the following, salt bridge is not needed?

(a) $Pb \mid PbSO_4(s) \mid H_2SO_4 \mid PbO_2(s) \mid Pb$
(b) $Cd \mid CdO(s) \mid KOH(aq) \mid NiO_2(s) \mid Ni$
(c) $Fe(s) \mid FeO(s) \mid KOH(aq), Ni_2O_3(s) \mid Ni$
(d) $Zn \mid ZnSO_4 \mid CuSO_4 \mid Cu$

Matching Column Type

20. Match the items of Column I and Column II on the basis of data given below:

$$E^\ominus_{F_2/F^-} = 2.87\text{ V},\quad E^\ominus_{Li^+/Li} = -3.5\text{ V}$$

$$E^\ominus_{Au^{3+}/Au} = 1.4\text{ V},\quad E^\ominus_{Br_2/Br^-} = 1.09\text{ V}$$

Column I		Column II	
(a)	F_2	(p)	Metal is the strongest reducing agent
(b)	Li	(q)	Metal ion which is the weakest oxidising agent
(c)	Au^{3+}	(r)	Non-metal which is the best oxidising agent
(d)	Br^-	(s)	Unreactive metal
(e)	Au	(t)	Anion that can be oxidised by Au^{3+}
(f)	Li^+	(u)	Anion which is the weakest reducing agent
(g)	F^-	(v)	Metal ion which is an oxidising agent

Integer Type

21. If E_1°, E_2° and E_3° are standard oxidation potentials for $Fe \mid Fe^{2+}$, $Fe^{2+} \mid Fe^{3+}$ and $Fe \mid Fe^{3+}$, then $E_3^\circ = \frac{E_2^\circ + 2E_1^\circ}{n}$. The value of n is ..... .

22. The no. of cells which may be constructed with different E°_{Cell} values for the reaction: $Fe + 2Fe^{3+} \rightarrow 3Fe^{2+}$.

Comprehension Type

The standard reduction potentials of some half reactions are given as below:

$$Cu^{2+} + e \rightarrow Cu^+;\quad E_1^\circ = 0.15\text{ V}$$

$$Cu^+ + e \rightarrow Cu;\quad E_2^\circ = 0.5\text{ V}$$

$$Ag^+ + e \rightarrow Ag;\quad E_3^\circ = 0.799\text{ V}$$

The decrease in free energy ($-\Delta G$) is responsible for the production of equivalent amount of electrical work. Thus, $-\Delta G = nF \times E$

23. The E°_{Cell} for $Cu \mid Cu^{2+}$ in volt is:

(a) 0.35
(b) –0.35
(c) +0.325
(d) –0.325

24. The E°_{cell} for $Cu \mid Cu^{2+} \parallel Ag^+ \mid Ag$ in volt is:

(a) +0.449
(b) +0.474
(c) –0.449
(d) –0.474

25. The E°_{cell} for $Cu|\underset{1\,M}{Cu^{2+}}||\underset{0.1\,M}{Ag^{+}}|Ag$ is:

(a) 0.415 V (b) 0.374 V
(c) –0.15 V (d) –0.374 V

26. In the cell $Ag \mid Ag^+ \parallel Cu^{2+}$ containing 1 M Cu^{2+} and 1 M Ag^+ ions, 9.65 ampere current is passed for 1 hour. Select the correct statement.

(1) Ag will oxidise to Ag^+ and new $[Ag^+] = 1.36$ M
(2) Ag^+ will reduce to Ag and new $[Ag^+] = 0.64$ M
(3) Cu^{2+} will reduce to Cu and new $[Cu^{2+}] = 0.82$ M
(4) Cu will oxidise to Cu^{2+} and new $[Cu^{2+}] = 0.82$ M

(a) 1, 3 (b) 2, 3
(c) 1, 4 (d) 2, 4

27. The e.m.f. of cell for spontaneous cell reaction having two electrodes as $Ag \mid Ag^+$ and $Cu \mid Cu^{2+}$ containing 1 M Cu^{2+} and 1 M Ag^+ ions after the passage of 9.65 ampere current for 1 hour will:

(a) increase by 0.010 V (b) decrease by 0.010 V
(c) increase by 0.020 V (d) decrease by 0.020 V

28. The total change in free energy during the cell reaction in $Cu \mid Cu^{2+} \parallel Ag^+ \mid Ag$ would be:

(a) –80.1 kJ (b) –40.05 kJ
(c) –31.36 kJ (d) –62.72 kJ

Answers Key

Single Correct Answer Type

5. (a) **6.** (a) **7.** (a) **8.** (d) **9.** (b)
10. (c) **11.** (b) **12.** (d) **13.** (a) **14.** (d)

Multiple Correct Answers Type

15. (a, b, c, d) **16.** (a, c) **17.** (a, d)
18. (a, c) **19.** (a, b, c)

Matching Column Type

20. (a → r), (b → p), (c → v), (d → t), (e → s), (f → q), (g → v, u)

Integer Type

21. (3) **22.** (3)

Comprehension Type

23. (d) **24.** (b) **25.** (a) **26.** (a) **27.** (a)
28. (a)

DPP 3.5

Nernst Equation and Its Applications

Subjective Type

1. How will the pH of brine (aq. NaCl solution) be affected when it is electrolysed?
2. From the standard cell potentials given below, calculate the indicated cell potential E°.

$$BrO_3^-(aq) \xrightarrow{0.54\ V} BrO^-(aq) \xrightarrow{0.45\ V} \frac{1}{2}Br_2(l)$$

$$\underbrace{BrO_3^-(aq) \longrightarrow \frac{1}{2}Br_2(l)}_{E^\circ}$$

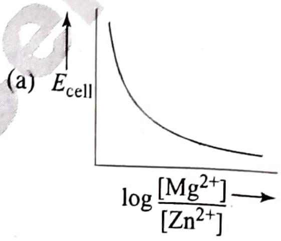
3. Write the Nernst equation for the cell reaction in the Daniell cell. How will the E_{cell} be affected when concentration of Zn^{2+} ions is increased?
4. (i) How can the reduction potential of an electrode be increased?
   (ii) Equilibrium constant is related to E°_{cell} but not to E_{cell}. Explain why?
   (iii) What is the free energy change for (a) galvanic cell (b) electrolytic cell?
5. An excess of solid AgCl is added to a 0.1 M solution of Br^- ions at 298 K. Calculate the concentrations of Cl^- and Br^- ions at equilibrium.
   Given: $E^\circ(Cl^-|Ag) = 0.222$ V and $E^\circ(Br^-|AgBr|Ag) = 0.095$ V.
6. Find the solubility product of a saturated solution of Ag_2CrO_4 in water at 298 K if the emf of the cell $Ag|Ag^+$ (satd. Ag_2CrO_4 soln.)$||Ag^+$ (0.1M)$|Ag$ is 0.164 V at 298 K.

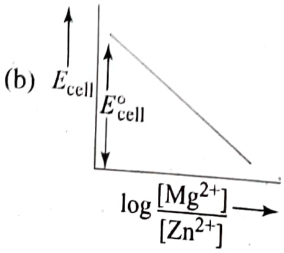
Single Correct Answer Type

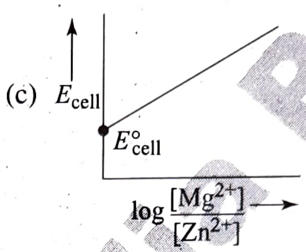
7. In the electrochemical cell,

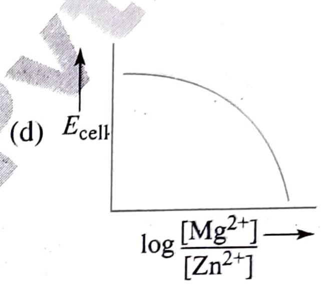
$$Mg(s)|Mg^{2+}(aq)\,||\,Zn^{2+}(aq)\,|\,Zn(s); \quad E^\circ = +3.13\ V$$

The correct plot of E_{cell} versus $\log\frac{[Mg^{2+}]}{[Zn^{2+}]}$ will be represented as:









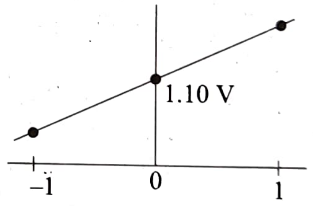
8. The overall cell reaction of Daniell cell is:

$$Zn(s) + Cu^{2+} \rightleftharpoons Zn^{2+} + Cu(s); \quad E^\circ = +1.10\ volt$$

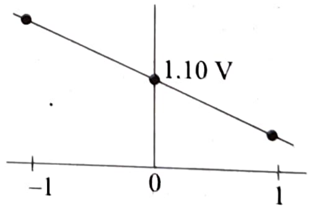
$$Q = \frac{[Zn^{2+}]}{[Cu^{2+}]}$$

When $\log_{10} Q$ is plotted on X-axis and E_{cell} on Y-axis, then which of the following will correctly represent the variation?

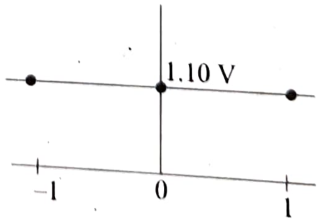
(a)



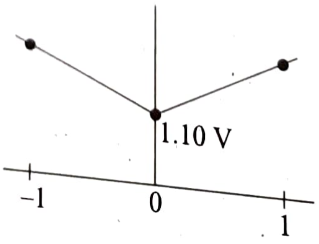
(b)



(c)



(d)



9. An alloy of Pb-Ag weighing 1.08 g was dissolved in dilute HNO_3 and the volume made to 100 mL. A silver electrode was dipped in the solution and the emf of the cell set-up, $Pt(s), H_2(g) | H^+(1M) || Ag^+(aq) | Ag(s)$ was 0.62 V. If E^o_{cell} is 0.80 V, what is the percentage of Ag in the alloy?

(At 25°C, RT/F = 0.06)

(a) 25 (b) 2.50

(c) 10 (d) 50

10. Determine the solubility and solubility product of $Co_2[Fe(CN)_6)]$ in water at 25°C from the following data: Conductivity of saturated solution of $Co_2[Fe(CN)_6]$ $= 2.06 \times 10^{-6}$ ohm^{-1} cm^{-1} and that of water $= 4.1 \times 10^{-7}$ ohm^{-1} cm^{-1}. The ionic molar conductivities of Co^{2+} and $[Fe(CN)_6]^{4-}$ are 86 and 444 ohm^{-1} cm^2 mol^{-1} respectively.

(a) 7.69×10^{-17} (b) 2.67×10^{-6}

(c) 9.68×10^{-6} (d) 8.23×10^{-17}

11. The standard reduction potential for the following two reactions are given:

$AgCl + e^- \rightarrow Ag(s) + Cl^-(aq)$; $E^o = 0.22$ V (i)

$Ag^+ (ag) + e^- \rightarrow Ag(s)$ $E_o = 0.80$ V (ii)

The solubility product of AgCl under standard condition will be:

(a) 1.613×10^{-5} M^2 (b) 1.535×10^{-8} M^2

(c) 3.213×10^{-10} M^2 (d) 1.535×10^{-10} M^2

12. Calculate the cell potential of following cell:

$Pt(s)|H_2(g)(0.1\ bar)|BOH(0.1\ M\ aq)|HA(0.1\ M)|H_2(g)$ (1 bar)|Pt

Given : $K_a = (HA) = 10^{-7}$, K_b (BOH) $= 10^{-5}$

(a) 0.40 V (b) 0.36 V

(c) 0.93 V (d) 0.63 V

13. For a cell reaction involving two electron charges, the standard emf of the cell is 0.295 V at 25°C. The equilibrium constant of the reaction at 25°C will be:

(a) 29.5×10^{-2} (b) 10

(c) 1×1^{10} (d) 2.95×10^{-10}

Multiple Correct Answers Type

14. A sample of water has a hardness expressed as 77.5 ppm Ca^{2+}. This sample is passed through an ion exchange column and the Ca^{2+} is replaced by H^+. Select the correct statement(s)–

(a) pH of the water after it has been so treated is 2.4

(b) Every Ca^{2+} ion is replaced by one H^+ ion

(c) Every Ca^{2+} ion is replaced by two H^+ ions

(d) pH of the solution remains unchanged

15. Which of the following expression(s) represent the voltage of cell at 298 K?

Ag (s) | AgI (saturated solution) || $Ag_2C_2O_4$ (saturated solution) | Ag(s)

(a) $E_{cell} = 0.0592 \log \dfrac{[Ag^+]AgI}{[Ag^+]Ag_2C_2O_4}$

(b) $E_{cell} = 0.0592 \log \dfrac{[Ag^+]Ag_2C_2O_4}{[Ag^+]AgI}$

(c) $E_{cell} = 0.0592 \log \dfrac{K_{sp}(Ag_2C_2O_4)}{K_{sp}(AgI)}$

(d) $E_{cell} = 0.0592 \log \dfrac{[2K_{sp}(Ag_2C_2O_4)]^{1/3}}{[K_{sp}(AgI)]^{1/2}}$

16. Consider the cell: Ag | AgCl (s) | KCl (1M) | $Hg_2Cl_2(s)$ | Hg (l) | Pt. The cell potential:

(a) increases on increasing concentration of Cl^- ions

(b) decreases or decreasing concentration of Cl^- ions

(c) is independent of concentration of Cl^- ions

(d) is independent of amounts of AgCl (s) and Hg_2Cl_2 (s)

17. The temperature coefficient of cell is $\left(\dfrac{\partial E}{\partial T}\right)_P$. Then:

(a) When $\left(\dfrac{\partial E}{\partial T}\right)_P = 0$, then $\Delta H = -nFE$

(b) When $\left(\dfrac{\partial E}{\partial T}\right)_P > 0$, the $nFE > \Delta H$ and it is endothermic reaction

(c) When $\left(\dfrac{\partial E}{\partial T}\right)_P < 0$, the $nFE < \Delta H$ and it is endothermic reaction

(d) When $\left(\dfrac{\partial E}{\partial T}\right)_P = 0$, then $\Delta H > nFE$ and it is endothermic reaction

18. In the following electrochemical cell:

$$Pt|H_2\,(x\ atm)|H^{\oplus}\,(pH = y)||Zn^{2+}\,(z\ M)|Zn$$

$E^{\ominus}_{cell} = E_{cell}$. This will be possible when

(a) $[Zn^{2+}] = [H^{\oplus}] = 1$ M and $p_{H_2} = 1$ atm

(b) $[Zn^{2+}] = 0.01, [H^{\oplus}] = 0.1$ M and $p_{H_2} = 1$ atm

(c) $[Zn^{2+}] = 1$ M, $[H^{\oplus}] = 0.1$ M and $p_{H_2} = 0.01$ atm

(d) $[Zn^{2+}] = [H^{\oplus}] = 0.1$ M and $p_{H_2} = 0.1$ atm

Matching Column Type

19. Match the Column I with Column II:

Column I (Combination of half-cell reactions)			**Column II** (Potential of overall process)	
(a)	$6OH^- + Br^- \rightleftharpoons BrO_3^- + 3H_2O + 6e^-$; $2OH^- + Br^- \rightleftharpoons BrO^- + H_2O + 2e^-$; $4OH^- + BrO^- \rightleftharpoons BrO_3^- + 2H_2O + 4e^-$	$E^o = -0.61$ V $E^o = -0.76$ V $E^o = ?$	(p)	$E^o = +1.56$ V
(b)	$H_2SO_3 + 4H^+ + 4e^- \rightleftharpoons S + 3H_2O$; $SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons H_2SO_3 + H_2O$; $SO_4^{2-} + 8H^+ + 6e^- \rightleftharpoons S + 4H_2O$;	$E^o = 0.45$ V $E^o = 0.17$ V $E^o = ?$	(q)	$E^o = -0.535$ V
(c)	$ClO_3^- + 6H^+ + 6e^- \rightleftharpoons Cl^- + 3H_2O$; $Cl_2 + 2e^- \rightleftharpoons 2Cl^-$; $ClO_3^- + 6H^+ + 5e^- \rightleftharpoons \frac{1}{2}Cl_2 + 3H_2O$;	$E^o = +1.45$ V $E^o = +1.36$ V $E^o = ?$	(r)	$E^o = +0.36$ V
(d)	$Zn^{2+}(aq) + 2e \longrightarrow Zn(s)$; $Ag^+ + e^- \longrightarrow Ag(s)$; $Zn(s) + 2Ag^+ \rightleftharpoons Zn^{2+}(aq) + 2Ag(s)$;	$E^o = -0.76$ V $E^o = +0.80$ V $E^o = ?$	(s)	$E^o = +1.47$ V

Integer Type

20. The voltage of the cell:

$Pb \mid PbSO_4 \mid Na_2SO_4.10H_2O \text{ (salt)} \mid Hg_2SO_4 \mid Hg$

is +0.9647 at 25°C. The temperature coefficient is 1.74×10^{-4} V. K^{-1}. Calculate the value of ΔS.

21. K_{sp} of $Cu(OH)_2$ is 1×10^{-19}. If reduction potential of Cu^{2+}/Cu couple is 0.1335 V in a solution and E^o for Cu^{2+}/Cu is 0.34 V, the pH of solution is ....

Comprehension Type

Tollen's reagent is used for the detection of aldehyde when a solution of $AgNO_3$ is added to glucose with NH_4OH, then gluconic acid is formed.

$Ag^+ + e^- \rightarrow Ag \qquad E^o = 0.8$ V

$C_6H_{12}O_6 + H_2O \rightarrow C_6H_{12}O_7 + 2H^+ + 2e^- \qquad E^0_{oxi} = -0.05$ V

$Ag(NH_3)_2^+ + e^- \rightarrow Ag(s) + 2NH_3 \qquad E^o = 0.337$ V

22. For the following reaction,

Glucose + H_2O + $2Ag^+ \overset{Keq}{\rightleftharpoons}$ Gluconic acid + 2Ag.

Determine the value of ln K_{eq}:

(a) 58.38 (b) 46.2

(c) 28.3 (d) 66.13

23. With the increase in concentration of NH_3, pH increases to 11. Consider there is no change in concentration of $C_6H_{12}O_6$ and $C_6H_{12}O_7$ on addition of NH_3.

Which of the following is correct?

(a) E_{ox} increases by 0.65 V from E^o_{ox}

(b) E_{ox} decreases by 0.65 V from E^o_{ox}

(c) E_{red} increases by 0.65 V from E^o_{red}

(d) E_{red} decreases by 0.65 V from E^o_{red}

24. Ammonia is always added in this reaction. Which of the following must be incorrect?

(a) NH_3 easily forms complex with Ag^+

(b) $Ag(NH_3)_2^+$ is a strong oxidising reagent than Ag^+.

(c) In absence of NH_3, silver salt of gluconic acid is formed.

(d) NH_3 has affected the standard reduction potential of glucose/gluconic acid electrode.

Answers Key

Subjective Type

2. 0.522 V **5.** 0.0993 M, 0.0007 M
6. 2.29×10^{-12} M^3

Single Correct Answer Type

7. (b) **8.** (b) **9.** (d) **10.** (a) **11.** (d)
12. (a) **13.** (c)

Multiple Correct Answers Type

14. (a, c) **15.** (b, d) **16.** (c, d) **17.** (a, b, c)
18. (a, b, c, d)

Matching Column Type

19. (a → q), (b → r), (c → s), (d → p)

Integer Type

20. (8) **21.** (8)

Comprehension Type

22. (a) **23.** (c) **24.** (d)

4

Chemical Kinetics

DPP 4.1

Rate Expression, Rate of Appearance and Disappearance, Instantaneous and Average Rate of Reaction

Subjective Type

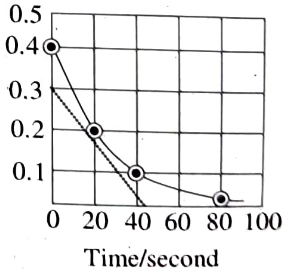
1. Hydrogenation of vegetable ghee at 25°C reduces the pressure of H_2 from 2 atm to 1.2 atm in 50 minute. Calculate the rate of reaction in terms of change:
   (a) In pressure per minute
   (b) In molarity per second.
2. In a reaction 2A → Products, the concentration of A decreases from 0.5 mol litre^{-1} to 0.4 mol litre^{-1} in 10 minute. Calculate the average rate during this interval.
3. A drop of solution (volume 0.05 ml) contains 3.0×10^{-6} mole of H^+. If the rate constant of disappearance of H^+ is 1.0×10^7 mole litre^{-1} sec^{-1}. How long would it take for H^+ in drop to disappear?
4. In a gaseous state reaction, $A_2(g) \rightarrow B(g) + (1/2)\,C(g)$, The increase in pressure from 100 mm to 120 mm is noticed in 5 minutes. The rate of disappearance of A_2 in mm min^{-1} is...

Single Correct Answer Type

5. For a gas reaction at T(K), the rate is given by $-\dfrac{dp_A}{dt} = k'p_A^2$ atm/hr. If the rate equation is expressed as: $-r_A = -\dfrac{1}{V}\dfrac{dn_A}{dt} = kC_A^2$, mol/(litre–hr), the rate constant k is given by
   (a) $k = k'$　　(b) $k = k'\,RT$
   (c) $k = k'/RT$　　(d) $k = k'\,(RT)^2$
   where R = ideal gas law constant, cal/g mol. K
6. In the following reaction: $xA \rightarrow yB$

$$\log\left[-\frac{d[A]}{dt}\right] = \log\left[\frac{dC}{dt}\right] + 0.3$$

   where –ve sign indicates rate of disappearance of the reactant. Thus, $x : y$ is:
   (a) 1 : 2　　(b) 2 : 1　　(c) 3 : 1　　(d) 3 : 10
7. A reaction follows the given concentration (C) vs time graph. The rate for this reaction at 20 seconds will be:

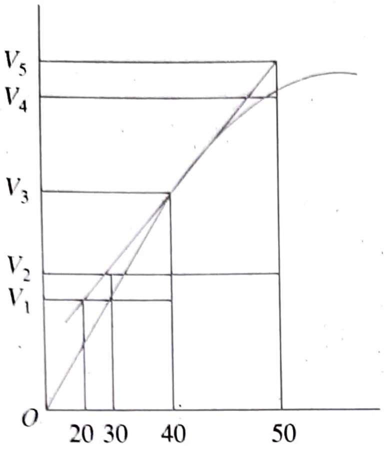


   (a) 4×10^{-3} ms^{-1}　　(b) 8×10^{-2} ms^{-1}
   (c) 2×10^{-2} ms^{-1}　　(d) 7×10^{-3} ms^{-1}
8. The instantaneous rate of disappearance of the MnO_4^- ion in the following reaction is 4.56×10^{-3} ms^{-1}. Then the rate of appearance of I_2 is:

$$2MnO_4^- + 10I^- + 10H^+ \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$$

   (a) 1.14×10^{-3} ms^{-1}　　(b) 5.7×10^{-3} ms^{-1}
   (c) 4.56×10^{-4} ms^{-1}　　(d) 1.14×10^{-2} ms^{-1}

9. A graph of volume of hydrogen released vs time for the reaction between zinc and dil. HCl is given in figure. On the basis of this mark the correct option.



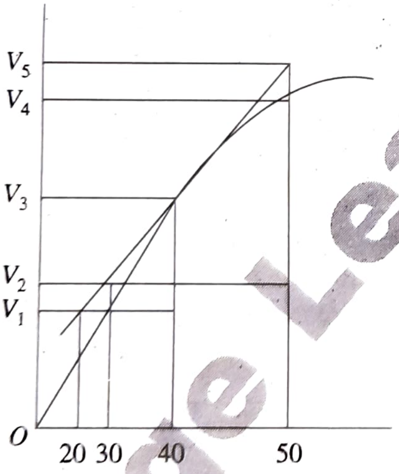
(a) Average rate up to 40 s is $\frac{V_3 - V_2}{40}$

(b) Average rate up to 40 s is $\frac{V_3 - V_2}{40 - 30}$

(c) Average rate up to 40 s is $\frac{V_3}{40}$

(d) Average rate up to 40 s is $\frac{V_3 - V_1}{40 - 20}$

10. Consider the graph given in figure. Which of the following options does not show instantaneous rate of reaction at 40 s?



(a) $\frac{V_5 - V_2}{50 - 30}$ (b) $\frac{V_4 - V_3}{50 - 30}$

(c) $\frac{V_3 - V_2}{40 - 30}$ (d) $\frac{V_3 - V_1}{40 - 20}$

Multiple Correct Answers Type

11. For the reaction, A + 3B → C, the differential form of the rate law is:

(a) $\frac{d[C]}{dt} = -\frac{d[A]}{dt}$ (b) $\frac{3d[C]}{dt} = \frac{-d[B]}{dt}$

(c) $\frac{-3d[B]}{dt} = \frac{-d[C]}{dt}$ (d) $\frac{d[A]}{dt} = \frac{d[C]}{dt}$

12. In acidic medium, the rate of reaction between BrO_3^- and Br^- is given by the expression $-\frac{d[BrO_3^-]}{dt} = k[BrO_3^-][Br^-][H^+]^2$. It means

(a) Rate constant of the reaction depends upon the concentration of H^+ ions.

(b) Rate of reaction is independent of the concentration of the acid added.

(c) The change in pH of the solution will affect the rate of reaction

(d) Doubling the concentration of H^+ ions will increase the reaction rate by 4 times.

13. The rate of gaseous reaction is generally expressed in terms of $\frac{dp}{dt}$. If it were expressed in terms of change in number of moles per unit time $\left(\frac{dn}{dt}\right)$ or in terms of change in molar concentration per unit time $\left(\frac{dc}{dt}\right)$, which of the following relationship will not hold good?

(a) $\frac{dc}{dt} = \frac{dn}{dt} = \frac{dp}{dt}$

(b) $\frac{dc}{dt} = \frac{1}{v}\left(\frac{dn}{dt}\right) = \frac{1}{RT}\left(\frac{dp}{dt}\right)$

(c) $\frac{dc}{dt} = \frac{dn}{dt} = \frac{v}{RT}\left(\frac{dp}{dt}\right)$

(d) $\frac{dc}{dt} = \frac{dn}{dt} = \frac{v^2}{RT}\left(\frac{dp}{dt}\right)$

14. In the following reaction, which is/are not correct expression regarding how the rate of appearance of the underlined product related to the disappearance of the underlined reactant?

$$BrO_3^-(aq) + 5\underline{Br^-}(aq) + 6H^+(aq) \longrightarrow 3\underline{Br_2}(\ell) + 3H_2O(\ell)$$

(a) $\frac{d[Br_2]}{dt} = -\frac{5}{3}\frac{d[Br^-]}{dt}$ (b) $\frac{d[Br_2]}{dt} = -\frac{d[Br^-]}{dt}$

(c) $\frac{d[Br_2]}{dt} = +\frac{d[Br^-]}{dt}$ (d) $\frac{d[Br_2]}{dt} = -\frac{3}{5}\frac{d[Br^-]}{dt}$

15. Which of the following expression can't be used to describe the instantaneous rate of the reaction?

$2A + B \rightarrow A_2B$

(a) $\frac{1}{2}\frac{-d[A]}{dt}$ (b) $\frac{-d[A]}{dt}$

(c) $\frac{1}{2}\frac{d[A_2B]}{dt}$ (d) $\frac{1}{2}\frac{-d[A]}{dt}\cdot\frac{d[B]}{dt}$

Integer Type

16. The following reaction was correct out in water :

$$Cl_2 + 2I^{\ominus} \longrightarrow I_2 + 2Cl^{\ominus}$$

The initial concentration of $I^{\ominus}$ was 0.25 mol L^{-1} and the concentration after 10 min was 0.23 mol L^{-1}. The rate of disappearance of $I^{\ominus}$ and rate of appearance of I_2 are of the form $y \times 10^{-3}$ mol L^{-1} min^{-1}. What is y for both?

17. If $\dfrac{d[NH_3]}{dt} = 34$ g hr^{-1} for the reaction

$N_2 + 3H_2 \rightarrow 2NH_3$

Then $\dfrac{d[H_2]}{dt}$ is ……. g hr^{-1}.

Comprehension Type

The reaction rate is the increase in molar concentration of product of a reaction per unit time or the decrease in molar concentration of reactant per unit time. However, also because of stoichiometry of the balanced chemical reaction, rates of reactions in terms of individual reactants and products are related.

$$m_1A + m_2B \rightarrow n_1C + n_2D$$

Instantaneous rate of reaction

$$= -\frac{1}{m_1}\frac{d[A]}{dt} = -\frac{1}{m_2}\frac{d[B]}{dt} = +\frac{1}{n_1}\frac{d[C]}{dt} = +\frac{1}{n_2}\frac{d[D]}{dt}$$

In appreciable interval of time, the average rate of reaction may be given as:

Average rate of reaction

$$= -\frac{1}{m_1}\frac{\Delta[A]}{\Delta t} = -\frac{1}{m_2}\frac{\Delta[B]}{\Delta t} = +\frac{1}{n_1}\frac{\Delta[C]}{\Delta t} = +\frac{1}{n_2}\frac{\Delta[D]}{\Delta t}$$

Answer the following questions:

18. Consider the chemical reaction.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

The rate of reaction may be expressed as:

(a) rate $= -\dfrac{d[N_2]}{dt} = -\dfrac{d[H_2]}{dt} = +\dfrac{d[NH_3]}{dt}$

(b) rate $= -\dfrac{d[N_2]}{dt} = -\dfrac{1}{3}\dfrac{d[H_2]}{dt} = +\dfrac{1}{2}\dfrac{d[NH_3]}{dt}$

(c) rate $= -\dfrac{d[N_2]}{dt} = +\dfrac{1}{3}\dfrac{d[H_2]}{dt} = -\dfrac{1}{2}\dfrac{d[NH_3]}{dt}$

(d) rate $= -\dfrac{d[N_2]}{dt} = -3\dfrac{d[H_2]}{dt} = +2\dfrac{d[NH_3]}{dt}$

19. For a chemical reaction,

$$m_1A + m_2B \rightarrow n_1C + n_2D$$

The ratio of rate of disappearance of A to that of appearance of C is:

(a) m_1/m_2 (b) m_2/n_1
(c) n_1/m_1 (d) m_1/n_1

20. In the following reaction,

$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

The rate of formation of SO_3 is 100 g min^{-1}. Hence, the rate of disappearance of O_2 is:

(a) 50 g min^{-1} (b) 20 g min^{-1}
(c) 100 g min^{-1} (d) 200 g min^{-1}

Answers Key

Subjective Type

1. 1.6×10^{-2} atm min^{-1}, 0.0327 **2.** 0.005 mol L^{-1} min^{-1}
3. 6×10^{-9} sec **4.** 8

Single Correct Answer Type

5. (d) **6.** (b) **7.** (d) **8.** (d) **9.** (c)
10. (b)

Multiple Correct Answers Type

11. (a, b) **12.** (c, d) **13.** (a, c, d)
14. (a, b, c) **15.** (b, c, d)

Integer Type

16. (2, 1) **17.** (6)

Comprehension Type

18. (b) **19.** (d) **20.** (b)

DPP 4.2

Rate Law, Law of Mass Action, Order of the Reaction, Molecularity

Subjective Type

1. For the reactions of I, II and III order, $k_1 = k_2 = k_3$ when concentrations are expressed in mol litre^{-1}. What will be the relation in k'_1, k'_2, k'_3, if concentrations are expressed in mol/mL?
2. The decomposition of ammonia on platinum surface follow the change,
   (a) If the decomposition is zero order, then what are the rate of production if N_2 and H_2, if $K = 2.5 \times 10^{-4}\ Ms^{-1}$?
   (b) If the rate obey $-\dfrac{d[NH_3]}{dt} = \dfrac{K_1[NH_3]}{1+K_2[NH_3]}$, what will be the order for decomposition of NH_3, if (i) $[NH_3]$ is very very less and (ii) $[NH_3]$ is very very high? K_1 and K_2 are constant.
3. Calculate the order of reaction for which rate becomes half if volume of container having same amount of reactant is doubled. (Assume gaseous phase reaction).
4. (i) The reaction $A + 2B \rightarrow C + 2D$ is run three times. In the second run, the initial concentration of A is double that in the first run, and the initial rate of the reaction is double that of the first run. In the third run, the initial concentration of each reactant is double the respective concentrations in the first run, and the initial rate is double that of the first run. What is the order of the reaction with respect to each reactant?
   (ii) The rate of the following reaction in aqueous solution, in which the initial concentration of the complex compound is 0.100 M, is to be studied:

$$[Co(NH_3)_5Cl]^{2+} + H_2O \longrightarrow [Co(NH_3)_5(H_2O)]^{3+} + Cl^-$$

Explain why under these conditions it is possible to determine the order of the reaction with respect to $[Co(NH_3)_5Cl]^{2+}$, but not with respect to water.

Single Correct Answer Type

5. Diazonium salt decomposes as $C_6H_5N_2^+Cl^- \rightarrow C_6H_5Cl + N_2$. At 0°C, the evolution of N_2 becomes two times faster when the initial concentration of the salt is doubled. Therefore, it is:
   (a) A first order reaction
   (b) A second order reaction
   (c) Independent of the initial concentration of the salt
   (d) A zero order reaction
6. For the chemical reaction $A + B + C \xrightarrow{K} D$, it was found that the rate of the reaction doubled when the concentration of B was doubled, that the rate of reaction doubled when the concentration of both A and B were doubled, and quadrupled when the concentration of both B and C were doubled. The order of the reaction is:
   (a) 2 (b) 3 (c) 4 (d) 6
7. Trimolecular reactions are uncommon because—
   (a) The probability of three molecules colliding at an instant is low
   (b) The probability of three molecules colliding at an instant is high
   (c) The probability of three molecules colliding at an instant is zero
   (d) The probability of many molecules colliding at an instant is high
8. For a reaction $pA + pB \rightarrow$ products, the rate law expression is $r = k[A]^1\ [B]^m$, then:
   (a) $(p + 1) < (1 + m)$
   (b) $(p + q) > (1 + m)$
   (c) $(p + q)$ may or may not be equal to $(1 + m)$
   (d) $(p + q) = (1 + m)$
9. For the irreversible process, $A + B \rightarrow$ products, the rate is first-order w.r.t. A and second-order w.r.t. B. If 1.0 mol each of A and B introduced into a 1.0 L vessel, and the initial rate was 1.0×10^{-2} mol L^{-1} s^{-1}, rate when half reactants have been turned into products is:
   (a) 1.25×10^{-3} mol L^{-1} s^{-}
   (b) 1.0×10^{-2} mol L^{-1} s^{-}
   (c) 2.50×10^{-3} mol L^{-1} s^{-}
   (d) 2.0×10^{-2} mol L^{-1} s^{-}
10. Which of the following statements is not correct about order of a reaction?
   (a) The order of a reaction can be a fractional number
   (b) Order of a reaction is experimentally determined quantity
   (c) The order of a reaction is always equal to the sum of the stoichiometric coefficients of reactants in the balanced chemical equation for a reaction
   (d) The order of a reaction is the sum of the powers of molar concentration of the reactants in the rate law expression.

11. For rate constant is numerically the same for three reactions of first, second and third order respectively. Which of the following is correct?

(a) if [A] = 1, then $r_1 = r_2 = r_3$
(b) if [A] < 1, then $r_1 > r_2 > r_3$
(c) if [A] > 1, then $r_3 > r_2 > r_1$
(d) All of the above

Multiple Correct Answers Type

12. The value of rate constant of a pseudo first order reaction ……….

(a) depends on the concentration of reactants present in small amount
(b) depends on the concentration of reactants present in excess
(c) is independent of the concentration of reactants
(d) depends only on temperature.

13. The rate law for the dimerisation of NO_2 is

$$\frac{-d[NO_2]}{dt} = k[NO_2]^2$$

Which of the following changes will change the value of the specific rate constant, k?

(a) Doubling the total pressure on the system
(b) Doubling the temperature
(c) Both of (a) and (b)
(d) None of the above

14. Which of the following statements is/are correct?

(a) Law of mass action and rate law expressions are same for single step reactions
(b) Order for the slowest elementary reaction of a multi step reaction gives the order of the multi step reaction
(c) Both order and molecularity have normally a maximum value of 3
(d) Molecularity of a complex reaction, $A + 2B \rightarrow C$ is 3

15. Which of the following statements is/are true?

(a) The order of a reaction can be zero
(b) The order of an elementary reaction is equal to its molecularity
(c) The order of the inversion of sucrose is 2
(d) The order of a reaction may change if the experimental conditions are changed.

16. The rate law for the reaction RCl + NaOH(aq) → ROH + NaCl is given by, rate = k_1 [RCl]. The rate of the reaction will be

(a) doubled on doubling the concentration of sodium hydroxide
(b) halved on reducing the concentration of alkyl halide to one half
(c) increased on increasing the temperature of the reaction
(d) unaffected by increasing the temperature of the reaction

Matching Column Type

17. Match the following:

	Column A		Column B
A.	$A + B \rightarrow C + D$ $r = K_1 [A][B]$	i:	Unit of rate constant possess concentration unit.
B.	$A + B \rightarrow C + D$ $r = k_2 [A][B]^\circ$	ii.	Rate constant for the reaction of both the reactants are equal
C.	$A + B \rightarrow C + D$ $r = K_3 [A]^\circ [B]^\circ$	iii.	Rate of consumption of at least one of the reactant is equal to rate of production of at least one of the products.
D.	$2A + B \rightarrow 2C + 3D$ $r = K_3 [A]^\circ [B]^\circ$	iv.	If both reactants are taken in stoichiometric ratio, half life for both reactants are equal.

Integer Type

18. Consider a reaction $aG + bH \rightarrow$ Products. When concentrations of both the reactants G and H are doubled, the rate increases by eight times. However, when concentration of G is doubled keeping the concentration of H fixed, the rate is doubled. The overall order of the reaction is … .

19. The rate of decomposition of a substance increases 2.25 times of concentration of reactant is increased by 1.5 times at same T. The order of reaction is … .

Comprehension Type

If the rates of forward and backward reaction in a chemical reaction become equal, the reaction is said to be in equilibrium state. At this state, reactants react to form products and products are converted into the same amount of reactants. Thus, it seems that the reaction has stopped, but the reaction keeps on going in both the directions at equal rates.

So, at Equilibrium $r_f = r_b$
where r_f = Rate of forward reaction
and r_b = Rate of backward reaction

Equilibrium constant is the ratio of the rate constant of forward reaction to rate constant of backward reaction $K_c = \frac{K_f}{K_b}$

For the reaction $A \rightarrow B + C$, the following data were obtained at 300° C.

Experiment	[A], mol L^{-1}	Rate, $mol^{-1} h^{-1}$
1	0.170	0.05
2	0.340	0.10
3	0.680	0.20

The equilibrium constant for the reaction is 0.50 mol L^{-1}. Assuming that the reaction proceeds by a one step mechanism.

20. What is the order of reaction for a forward reaction?
(a) 0 (b) 1 (c) 2 (d) 1.5

21. What is rate constant for a backward reaction?
(a) 0.294 L mol^{-1} hr^{-1} (b) 0.588 L mol^{-1} hr^{-1}
(c) 0.50 L mol^{-1} hr^{-1} (d) 0.125 L mol^{-1} hr^{-1}

Answers Key

Single Correct Answer Type

5. (a) **6.** (a) **7.** (a) **8.** (c) **9.** (a)
10. (c) **11.** (d)

Multiple Correct Answers Type

12. (a, b) **13.** (b) **14.** (a, b, c)
15. (a, b, d) **16.** (b, c)

Matching Column Type

17. (A → i, ii, iii, iv) (B → ii, iii, iv) (C → i, ii, iii, iv) (D → iii, iv)

Integer Type

18. (3) **19.** (2)

Comprehension Type

20. (b) **21.** (a)

DPP 4.3

Integrated Rate Expression

Subjective Type

1. Compounds A and B react with a common reagent with first order kinetics in both cases. If 99% of A must react before 1% of B has reacted. What is the minimum ratio for their respective rate constants?

   (Given $\frac{2}{2-\log 99} = 458$)

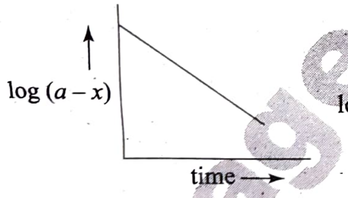
2. The decomposition of Cl_2O_7 at 400 K in the gas phase to Cl_2 and O_2 of I order. After 55 sec at 400 K, the pressure of Cl_2O_7 falls from 0.062 to 0.044 atm, calculate :
   (a) The rate constant
   (b) Pressure of Cl_2O_7 after 100 sec.

3. The reaction $SO_2Cl_2(g) \rightarrow SO_2(g) + Cl_2(g)$ is a first order gas reaction with $k = 2.2 \times 10^{-5}$ sec^{-1} at 320°C. What % of SO_2Cl_2 is decomposed on heating this gas for 90 min?

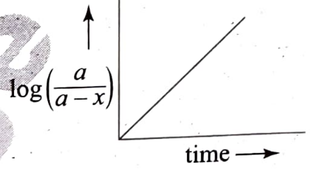
4. The half-life of the reaction N_2O_5 (g) $\rightarrow 2NO_2(g) + \frac{1}{2} O_2(g)$ is 2.4 h at 30°C.
   (a) Starting with 10 g, what is the mass of N_2O_5 left after 9.6 h?
   (b) How much time is required to reduce 5.0×10^{10} molecules of N_2O_5 to 1.0×10^8 molecules?

Single Correct Answer Type

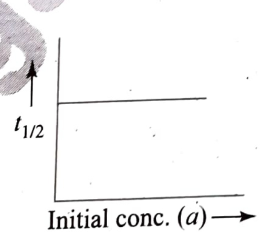
5. Which of the following is/are correct for the first order reaction?



(I)



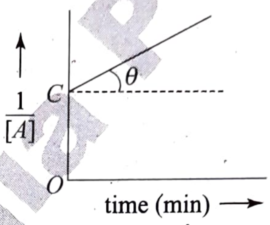
(II)



(III)

(a) I, II (b) II, III
(c) I, II, III (d) I, III

6. For a second order reaction, A → Product, the graph is plotted against $\frac{1}{[A]}$ and time 't'.



$\tan\theta = 0.6$ and OC = 2 L mol^{-1}. The rate of reaction at beginning is:
(a) 1.25 mol L^{-1} min^{-1} (b) 0.150 mol L^{-1} min^{-1}
(c) 0.5 mol L^{-1} min^{-1} (d) 1.50 mol L^{-1} min^{-1}

7. For a first order reaction, the plot of 't' against log C gives a straight line with slope equal to
(a) $\frac{k}{2.303}$ (b) $-\frac{k}{2.303}$
(c) $\frac{\ln k}{2.303}$ (d) $-k$

8. In a first order reaction, the reactant substance has half-life period of ten minutes. What fraction of the substance will be left after an hour the reaction has occurred ?
(a) 1/6 of initial concentration
(b) 1/64 of initial concentration
(c) 1/12 of initial concentration
(d) 1/32 of initial concentration

9. Two substances A ($t_{1/2} = 5$min) and ($t_{1/2} = 15$ min) are taken in such a way that initially [A] = 4[B]. The time after which both the concentration will be equal is (assuming reactions are of 1st order) :
(a) 5 min
(b) 15 min
(c) 20 min
(d) concentration can never be equal

10. The rate constant for the reaction A → B is 2×10^{-4} lt. mol^{-1}. The concentration of A at which rate of the reaction is $(1/12) \times 10^{-5}$ M sec^{-1} is:
(a) 0.25 M (b) $(1/20)\sqrt{5/3}$ M
(c) 0.5 M (d) None of these

11. In presence of HCl, sucrose gets hydrolysed into glucose and fructose. The concentration of sucrose was found to reduce from 0.4 M to 0.2 M in 1 hour and to 0.1 M in total of 2 hours. The order of the reaction is
(a) zero (b) one
(c) two (d) None of these

Multiple Correct Answers Type

12. The specific rate constant of a first order reaction is independent of the:
(a) concentration of the reactants
(b) time
(c) temperature
(d) activation energy

13. For a I-order reaction

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

(a) the concentration of the reactant decreases exponentially with time
(b) the half-life of the reaction decreases with increasing temperature
(c) the half-life of the reaction depends on the initial concentration of the reactant
(d) the reaction proceeds to 99.6% completion in eight half-life duration.

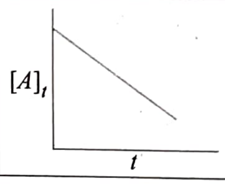
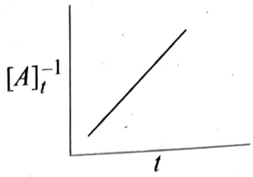
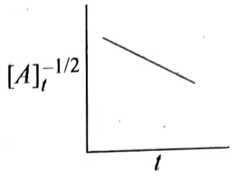
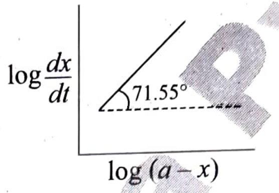
14. Which of the following relationship(s) are correct for 1st order reaction?
(a) $t_{75\%} = 2t_{1/2}$ (b) $t_{87.5\%} = 3t_{1/2}$
(c) $t_{99.9\%} = 9t_{1/2}$ (d) $t_{96.87\%} = 4t_{1/2}$

15. In a 1st order reaction, amount of the substance left after n half lives and average life of a 1st order reaction respectively are
(a) $\frac{[A_0]}{2^n}, \frac{1}{k}$ (b) $\frac{[A_0]}{n^2}, \frac{1}{k}$
(c) $\frac{[A_0]}{n2^n}, 1.44 \times t_{1/2}$ (d) $\frac{[A_0]}{n^2}, 1.44 t_{1/2}$

16. If the reactant 'A' is gaseous and pressures are measured instead of molar concentrations, then for reactions of zero order,
(a) $k = \frac{1}{t}[p_o - p_A]; t_{1/2} = \frac{p_o}{2k}$
(b) $k = \frac{1}{t}[p_A - p_o]; t_{1/2} = \frac{p_o}{k}$
(c) $k = \frac{1}{t}[p_o - p_A]$; decrease in pressure of the gaseous reactant A ∝ time
(d) $k = \frac{1}{t}[p_A - p_o]$; decrease in pressure of the gaseous reactant $= kt$

Matching Column Type

17. Only one match is possible:

Column I		Column II	
A.		1.	O.R. = 1/2
B.		2.	O. R. = zero
C.		3.	O. R. = 2
D.		4.	O. R. = 3

Integer Type

18. A straight line was obtained on plotting $\log_{10}\frac{dx}{dt}$ vs. $\log_{10}(a-x)^n$ with an intercept on $\log\left(\frac{dx}{dt}\right)$ axis to 0.6021. The rate constant for the reaction is .... litre^{n-1} mol^1 t^{-1}.

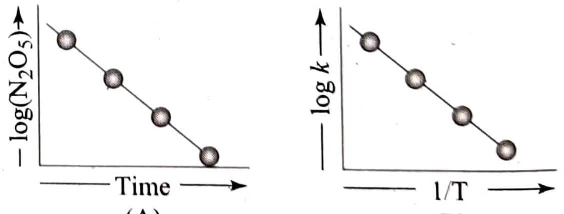
19. The half-life period of a reaction, becomes 16 times when reactant concentration is solved. The order of reaction is ......

Comprehension Type

Dinitrogen pentoxide decomposes to NO_2 and O_2 following first order kinetics.

$$N_2O_5(g) \rightarrow 2NO_2 + O_2 (g)$$

0.2 mole of N_2O_5 was taken in 2 L vessel and heated at 200 K. The concentration of N_2O_5 is measured at different intervals. Following graphs A and B were obtained from the data.



(A) (B)

20. Slope of straight line in graph 'A' is -1.2×10^2 sec^{-1}. What is half life of the reaction?
(a) 2.5×10^{-2} s (b) 2.5×10^{-3} s
(c) 12.5×10^{-4} (d) 2.5×10^{-3} m

21. Calculate the rate of reaction after 5×10^{-3} s.
(a) 6.84 mol L^{-1} s^{-1} (b) 3.42 mol L^{-1} s^{-1}
(c) 6.84 mol L^{-1} (d) 6.84 mol s^{-1}

Answers Key

Subjective Type

1. 458 **2.** (a) $6.23 \times 10^{-3}\ \text{sec}^{-1}$ (b) 0.033 atm
3. 11.2% **4.** (a) 0.625 g (b) 21.52 h

Single Correct Answer Type

5. (c) **6.** (b) **7.** (b) **8.** (b) **9.** (b)
10. (b) **11.** (b)

Multiple Correct Answers Type

12. (a, b) **13.** (a, b, d) **14.** (a, b) **15.** (a, c)
16. (a, c)

Matching Column Type

17. (A → 2), (B → 3), (C → 1), (D → 4)

Integer Type

18. (4) **19.** (5)

Comprehension Type

20. (b) **21.** (a)

DPP 4.4

Initial Rate Method and Ostwald Method

Subjective Type

1. For the chemical reaction between mercuric chloride and potassium oxalate, the mass of Hg_2Cl_2 precipitated from different situations in a given time at 100°C is given in following table.

Exp. No.	$HgCl_2$ (mol L^{-1})	$K_2Cr_2O_7$ (mol L^{-1})	Time (min.)	Hg_2Cl_2 (mol L^{-1})
1.	0.0836	0.404	65	0.0068
2.	0.0836	0.0202	120	0.0031
3.	0.0418	0.0404	60	0.0032

From these data, calculate the order of reaction.

2. Write the rate law expression and find the rate constant of the reaction $A + B \rightarrow$ Product. Also calculate half-life period.

$[A_0]$ Mol litre^{-1}	$[B_0]$ Mol litre^{-1}	Rate $[R_0]$ Mol litre^{-1} sec^{-1}
0.1	0.2	0.05
0.2	0.2	0.10
0.1	0.1	0.05

3. For a reaction at 800°C, $2NO + 2H_2 \rightarrow N_2 + 2H_2O$, the following data were obtained.

	$[NO]\times10^{-4}$ Mol litre^{-1}	$[H_2]\times10^{-3}$ Mol litre^{-1}	$-\frac{1}{2}d[NO]/dt\times10^{-4}$ Mol litre^{-1} min^{-1}
(i)	1.5	4.0	4.4
(ii)	1.5	2.0	2.2
(iii)	0.5	2.0	0.24

What is the order of this reaction with respect to NO and H_2? Also calculate the rate constant.

4. Rate of a reaction, $A + B \rightarrow$ Product is given as a function of different initial concentrations of A and B.

$[A]$/Mol L^{-1}	$[B]$/Mol L^{-1}	r_0/mol L^{-1} min^{-1}
0.01	0.01	0.005
0.02	0.01	0.010
0.01	0.02	0.005

Determine the order of the reaction with respect to A and with respect to B. What is the half-life of A in the reaction?

Single Correct Answer Type

5. The experimental data for the reaction, $2A + B_2 \rightarrow 2AB$, is

Expt. No.	$[A]$	$[B_2]$	Rate (s^{-1})
1.	0.50	0.50	1.6×10^{-4}
2.	0.50	1.00	3.2×10^{-4}
3.	1.0	1.00	3.2×10^{-4}

The rate equation for the above data is -
(a) rate $= k[B_2]^2$ (b) rate $= k[B]$
(c) rate $= k[A]^2[B]^2$ (d) rate $= k[A]^2[B]$

6. For a chemical reaction $A \rightarrow B$, the rate of reaction increases by a factor of 1.837 when the concentration of A is increased by 1.5 times. The order of reaction with respect to A is:
(a) 1 (b) 1.5 (c) 2 (d) −1

7. For the decomposition of HI at 1000 K ($2HI \rightarrow H_2 + I_2$), the following data were obtained:

$(HI)_1$M	Rate of decomposition of HI (mol L^{-1} s^{-1})
0.1	2.75×10^{-8}
0.2	11×10^{-8}
0.3	24.75×10^{-8}

The order of reaction is:
(a) 1 (b) 2 (c) 0 (d) 1.5

8. The rate of the reaction

$$3A+2B\longrightarrow\text{Products}$$

is given by the rate expression : rate $= k[A][B]^2$
If A is taken in excess, the order of the reaction would be
(a) 3 (b) 2 (c) 1 (d) 5

9. For the non-stoichiometric reaction, $2A + B \rightarrow C + D$, the following kinetic data were obtained in three separate experiments, all at 298 K.

Initial concentration (A)	Initial concentration (B)	Initial rate of formation of C (C)
0.1 M	0.1 M	1.2×10^{-3}
0.1 M	0.2 M	1.2×10^{-3}
0.2 M	0.1 M	2.4×10^{-3}

The rate law for the formation of C is

(a) $\left[\frac{dC}{dt}\right] = k[A][B]$ (b) $\frac{dC}{dt} = k[A]^2[B]$

(c) $\frac{dC}{dt} = k[A][B]^2$ (d) $\frac{dC}{dt} = k[A]$

10. The data for the reaction: $A + B \xrightarrow{k} C$.

Experiment	$[A]_0$	$[B]_0$	Initial rate
1	0.012	0.035	0.10
2	0.024	0.070	0.80
3	0.024	0.035	0.10
4	0.012	0.070	0.80

The rate law corresponding to the above data is

(a) Rate = $k[B]^3$ (b) Rate = $k[B]^4$

(c) Rate = $k[A]\,[B]^3$ (d) Rate = $k[A]^2\,[B]^2$

11. For a hypothetical reaction $A + B \rightarrow C$, suggest order from the following data:

Experiment	[A] (mol L^{-1})	[B] (mol L^{-1})	Rate of reaction (mol $L^{-1}s^{-1}$)
I	0.25	0.25	3.0×10^{-3}
II	0.50	0.25	6.0×10^{-3}
III	0.50	0.50	1.20×10^{-2}

(a) 0 (b) 1 (c) 2 (d) 3

Multiple Correct Answers Type

12. In a certain gaseous reaction between A and B, $A + 3B \rightarrow AB_3$. The initial rates are reported as follows :

[A]	[B]	Rate
0.1 M	0.1 M	0.002 Ms^{-1}
0.2 M	0.1 M	0.002 Ms^{-1}
0.3 M	0.2 M	0.008 Ms^{-1}
0.4 M	0.3 M	0.018 Ms^{-1}

Which of the following statement(s) is/are correct?

(a) The rate law is $\Rightarrow$ $r = k[A]^0[B]^3$

(b) The rate law is $\Rightarrow$ $r = k[A]^0[B]^2$

(c) The overall of the reaction is 2 and is zero order w.r.t [A]

(d) The overall order of the reaction is 3 and is of 3rd order w.r.t [B]

13. Select the incorrect statements regarding law that corresponds to data shown for the following reaction:

$A + B \rightarrow$ Products

Exp.	[A]	[B]	Rate
1	0.012	0.035	0.1
2	0.024	0.070	0.8
3	0.024	0.035	0.1
4	0.012	0.070	0.8

(a) Rate = $k[B]^3$ (b) Rate = $k[B]^4$

(c) Rate = $k[A]\,[B]^3$ (d) Rate = $k[A]^2\,[B]^3$

14. $A + B \rightarrow C$

Exp.	[A]	[B]	Rate
1	1.0	1.0	0.25
2	2.0	1.0	0.50
3	1.0	2.0	0.25

Rate is expressed in mol L^{-1} min^{-1}.

Select the incorrect options regarding order:

(a) Zero in A and one in B

(b) One in A and zero in B

(c) One in both A and B

(d) Zero in both A and B

15. For the chemical reaction

$A + B + C \rightarrow E$

The rate of reaction is doubled when concentration of B was doubled, and when the concentration of both A and B were doubled the rate becomes doubled and when the concentration of both B and C were doubled the rate becomes quadrupled.

(a) Order w.r.t. B, A and C are 1, 0 and 1 respectively.

(b) The reaction is first order w.r.t. B and C and total order is 2.

(c) The rate law is $r = k[B]\,[C]$

(d) The rate law is $r = k[A]^{1/2}\,[B]\,[C]$

16. The bromination of acetone that occurs in acid solution is represented by

$$CH_3COCH_3(aq) + Br_2(aq) \rightarrow CH_3COCH_2Br_2(aq) + HBr(aq)$$

Given

Experiment	Initial concentrations, M			Initial rate, Disappearance of Br_2, Ms^{-1}
	$[Br_2]$	$[CH_3COCH_3]$	$[H^+]$	
1	0.050	0.30	0.050	5.7×10^{-5}
2	0.10	0.30	0.050	5.7×10^{-5}
3	0.10	0.30	0.10	1.2×10^{-4}
4	0.050	0.40	0.20	3.1×10^{-4}

Based on the above data, which don't represent rate law are :

(a) $\left(\frac{dx}{dt}\right) = k[CH_3COCH_3][Br_2][H^+]$

(b) $\left(\frac{dx}{dt}\right) = k[CH_3COCH_3][H^+]$

(c) $\left(\frac{dx}{dt}\right) = k[CH_3COCH_3][Br_2]$

(d) $\left(\frac{dx}{dt}\right) = k[CH_3COCH_3][Br_2][H^+]^2$

Matching Column Type

17. Match the following:

	Column I (Rate law)		Column II (Order)
(a)	Rate = $k \times$ Intensity of light	(p)	Second order
(b)	Rate = $k\,[A]^1\,[B]^1$	(q)	Zero order
(c)	Rate = $k\,[A]^{3/2}\,[B]^{1/2}$	(r)	First order when A is in excess
(d)	Rate = $k\,[A]^2\,[B]^1$	(s)	Second order when B is in excess

Integer Type

18. The following rate data were obtained at 303 K for the following reaction:

$$2A + B \rightarrow C + D$$

Experiment	$[A]$/mol L^{-1}	$[B]$/mol L^{-1}	Initial rate of formation of D/mol L^{-1} min^{-1}
I	0.1	0.1	6.0×10^{-3}
II	0.3	0.2	7.2×10^{-2}
III	0.3	0.4	2.88×10^{-1}
IV	0.4	0.1	2.4×10^{-2}

Calculate the rate constant.

19. For the decomposition of HI at 1000 K ($2HI \rightarrow H_2 + I_2$), following data were obtained.

[HI] (M)	Rate of decomposition of HI (mol L^{-1} s^{-1})
0.1	2.75×10^{-8}
0.2	11×10^{-8}
0.3	24.75×10^{-8}

The order of reaction is .... .

Comprehension Type

Suppose 50 bacteria are placed in a flask containing nutrients for the bacteria so that they can multiply. A study at 35°C gave the following results.

Time (Minutes)	0	15	30	45	60
Number of Bacteria	100	200	400	800	1600

Then :

20. This multiplication of bacteria follows a:
(a) Zero order reaction (b) 1st order reaction
(c) 2nd order reaction (d) 3rd order reaction

21. The rate constant for the reaction is:
(a) 0.0462 min^{-1} (b) 0.462 min^{-1}
(c) 4.62 min^{-1} (d) 46.2 min^{-1}

22. The rate of the reactions initially is –
(a) 4.62 bacteria's per minute
(b) 23.1 bacteria's per minute
(c) 23.1 bacteria's per sec
(d) 0.231 bacteria's per sec

Answers Key

Subjective Type

1. 3 2. 0.5 sec^{-1}, 1.386 sec^{-1}
3. 2, 1, 4.88×10^{-8} mol^{-2} L^2 min^{-1}
4. 1.386 min

Single Correct Answer Type

5. (b) 6. (b) 7. (b) 8. (b) 9. (d)
10. (a) 11. (c)

Multiple Correct Answers Type

12. (b, c) 13. (b, c, d) 14. (a, c, d) 15. (a, b, c)
16. (a, c, d)

Matching Column Type

17. (a → q) (b → p) (c → p) (d → r, s)

Integer Type

18. (6) 19. (2)

Comprehension Type

20. (b) 21. (a) 22. (a)

DPP 4.5

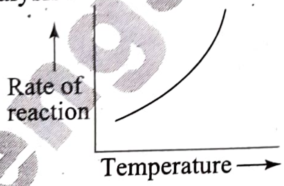
Arrhenius Equation, Effect of Temperature and Effect of Catalysts

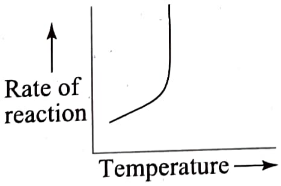
Subjective Type

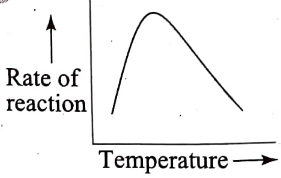
1. A 1st order chemical reaction was carried out for 1.0 hour in absence of a catalyst and 20% reaction was complete. A catalyst was then added and reaction was allowed to continue for next 30 min. when 60% reaction was complete. A second catalyst was then added at this time and reaction was allowed to continue for further 10 min. when 90% reaction was complete. If activation energy of the original path was 50 kJ. Determine activation energies of catalyzed pathways. Assume constant temperature throughout to be 300 J.
2. (i) For a certain reaction large fraction of molecules has energy more than the threshold energy, yet the rate of reaction is very slow. Why?
   (ii) For a zero order reaction will the molecularity be equal to zero? Explain.
3. The reaction between $H_2(g)$ and $O_2(g)$ is highly feasible yet allowing the gases to stand at room temperature in the same vessel does not lead to the formation of water. Explain.
4. A Ist order reaction is 50% complete in 30 minute at 27°C and in 10 minutes at 47°C. Calculate the:
   (a) rate constant for reaction at 27°C and 47°C
   (b) energy of activation for the reaction
   (c) energy of activation for the reverse reaction if heat of reaction is – 500 kJ mol^{-1}.
5. At 380°C, the half-life period for the first order decomposition of H_2O_2 is 360 minutes. The energy of activation of the reaction is 200 kJ mol^{-1}. Calculate the time required for 70% decomposition at 450°C.

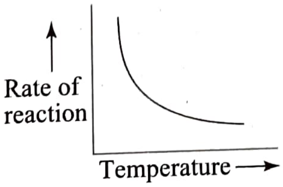
Single Correct Answer Type

6. Which of the following graphs is correct for the enzyme catalysis?

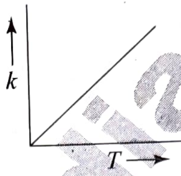
(a) 

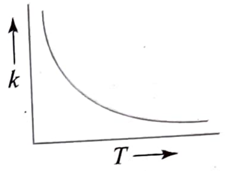
(b) 

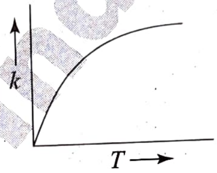
(c) 

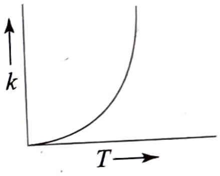
(d) 

7. The rate constant of most of the reactions increases with increase in temperature. According to the Arrhenius equation, $k = Ae^{-E_a/RT}$. The curve of rate constant 'k' against temperature 'T' will be

(a) 

(b) 

(c) 

(d) 

8. Which is incorrect from the theory of Arrhenius's equation?
   (a) The number of effective collisions is proportional to the number of molecules above a certain threshold energy.
   (b) As the temperature increases, the number of molecules with energies exceeding the threshold energy increases.
   (c) The rate constant is a function of temperature
   (d) Activation energy and pre-exponential factors are temperature-dependent.
9. The velocity of a reaction is doubled for every 10°C rise in temperature. If the temperature is raised by 50°C, the reaction velocity increases by about:
   (a) 12 times (b) 16 times
   (c) 32 times (d) 50 times
10. The decomposition of N_2O into N_2 and O_2 in presence of gaseous argon follow second order kinetics with $k = (5.0 \times 10^{11}\ L\ mol^{-1}\ s^{-1})\ e^{-\frac{41570K}{T}}$ (K stands for Kelvin units). The energy of activation of the reaction is
    (a) 5.0×10^{11} J (b) 41570 J
    (c) 5000 J (d) 345612.98 J
11. How much faster would a reaction proceed at 25°C than at 0°C if the activation energy is 65 kJ?
    (a) 2 times (b) 5 times
    (c) 11 times (d) 16 times
12. By increasing the temperature by 10°C, the rate of forward reaction at equilibrium is increased by a factor of 2. The rate of backward reaction by this increase in temperature
    (a) remains unaffected
    (b) increases by a factor greater than two

(c) decreases by a factor lesser than two
(d) is also increased by a factor of two

13. For the reaction $A(g) \rightleftharpoons B(g)$ $\Delta H = -40$ kJ mol^{-1}. If $E_f/E_b = 2/3$, then

(a) $E_f = 60$ kJ mol^{-1}; $E_b = 100$ kJ mol^{-1}
(b) $E_f = 30$ kJ mol^{-1}; $E_b = 70$ kJ mol^{-1}
(c) $E_f = 80$ kJ mol^{-1}; $E_b = 120$ kJ mol^{-1}
(d) $E_f = 70$ kJ mol^{-1}; $E_b = 30$ kJ mol^{-1}

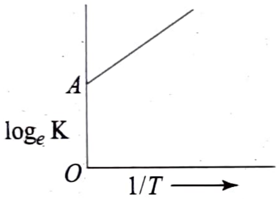
14. The activation energies of two reactions are E_{a1} and E_{a2} with $E_{a1} > E_{a2}$. If the temperature of the reacting system is increased from T_1 to T_2, predict which of the following alternatives is correct?

(a) $\frac{k_1'}{k_1} = \frac{k_2'}{k_2}$ (b) $\frac{k_1'}{k_1} > \frac{k_2'}{k_2}$

(c) $\frac{k_1'}{k_1} < \frac{k_2'}{k_2}$ (d) $\frac{k_1'}{k_1} < 2\frac{k_2'}{k_2}$

where k' s are the rate constants at higher temperatures.

15. A graph between $\log_e$ K and $\frac{1}{T}$ is of the type



Thus,

(a) $\Delta H^o > 0$ and $\Delta A^o = \frac{\Delta S^o}{R}$

(b) $\Delta H^o < 0$ and $\Delta A^o = \frac{\Delta S^o}{R}$

(c) $\Delta H^o > 0$ and $\Delta A^o = -\frac{\Delta S^o}{R}$

(d) $\Delta H^o < 0$ and $\Delta A^o = -\frac{\Delta S^o}{R}$

Multiple Correct Answers Type

16. Arrhenius equation may be written as:
(a) $(d/dT) \log k = -(\Delta E/RT^2)$
(b) $(d/dT) \log k = +(\Delta E/RT^2)$
(c) $(d/dT) \log k = -(\Delta E/RT)$
(d) $k = Ae^{\Delta E/RT}$

17. Rate constant for a reaction varies with temperature as, $\ln k\,(\text{sec}^{-1}) = 14.34 - \frac{1.25 \times 10^4}{T}$, which statement(s) is/are correct?

(a) The graph plotted in between $\log_{10} k$ vs $\frac{1}{T}$ is straight line with $E_a = 24.83$ kcal
(b) Pre-exponential factor = 14.34
(c) The rate constant at 500 K is 2.35×10^{-5} sec^{-1}
(d) $E_a = 30.63$ kcal

18. For a reaction activation energy for the forward reaction is 50 kJ and for backward reaction is 30 kJ. Which of the following are true for the reaction?
(a) Reaction is endothermic
(b) Reaction is exothermic
(c) Threshold energy is 80 kJ
(d) $\Delta E = 20$ kJ

19. During decomposition of an activated complex
(a) energy is always released
(b) energy is always absorbed
(c) energy does not change
(d) reactants may be formed

20. Which of the following statements is/are correct?
(a) The catalyst changes not only the rate of forward direction but also that of backward direction
(b) The catalyst changes the value of equilibrium constant of the reaction
(c) The mechanism of a catalyst reaction depends on the type of catalyst, i.e., whether it is homogeneous or heterogeneous
(d) Enzymes are essentially proteins which catalyze reaction occurring in living matter.

Matching Column Type

21. Match the statements given in Column I and Column II.

	Column I		Column II
A.	Catalyst alters the rate of reaction	1.	Cannot be fraction or zero
B.	Molecularity	2.	Proper orientation is not there
C.	Second half-life of first order reaction	3.	By lowering the activation energy
D.	$e^{-E_a/RT}$	4.	Is same as the first
E.	Energetically favourable reactions are sometimes slow	5.	Total probability is one
F.	Area under the Maxwell, Boltzmann curve is constant.	6.	Refers to the fraction of molecules with energy equal to or greater than activation energy.

Integer Type

22. If the rate of reaction is 2.6×10^{-3} mol L^{-1} s^{-1} at 50°C and 7.02×10^{-2} mol L^{-1} s^{-1} at 80°C, then what will be the temperature coefficient of the reaction?

23. Energy of activation for a reversible reaction is 6 kcal (E_a forward) and heat of reaction is – 3 kcal. The energy of activation for backward reaction in kcal is ……..

Comprehension Type

The rates of chemical reactions are strongly affected by temperature. Arrhenius (1889) gave following relation between rate constant and temperature:

$$k = A\,e^{-E_a/RT} \qquad \text{(i)}$$

This equation is called Arrhenius equation. The constant 'A' is called Arrhenius constant or pre-exponential factor. Logarithm of equation (i) is given as:

$$\log_{10} k = \log_{10} A - \frac{E_a}{2.303RT} \qquad \text{(ii)}$$

The rate constant for a reaction is:

$$\log_{10} k\,\text{sec}^{-1} = 14 - \frac{1.25 \times 10^4\,\text{K}}{T} \qquad \text{(iii)}$$

Answer the following questions:

24. The pre-exponential factor or frequency factor of the reaction under consideration is:
(a) 1.25×10^4 sec^{-1} (b) 10^{-14} sec^{-1}
(c) 10^{14} sec^{-1} (d) 14 sec^{-1}

25. At what temperature, rate constant of the reaction is equal to the pre-exponential factor?
(a) $T = 0$ K (b) $T = \infty$ K
(c) $T = \dfrac{1.25 \times 10^4}{14}$ K (d) $T = \dfrac{14}{1.25 \times 10^4}$ K

26. Energy of activation in kcal mol^{-1} is:
(a) 14 kcal mol^{-1} (b) 57.2 kcal mol^{-1}
(c) 1.25×10^4 kcal mol^{-1} (d) $\dfrac{14}{1.25 \times 10^4}$ kcal mol^{-1}

27. The intercept of the plot of $\log_{10} k$ against 1/T is equal to:
(a) $\log_{10} A$ (b) A
(c) $\dfrac{E_a}{2.303R}$ (d) E_a

Answers Key

Subjective Type

1. 75.44 kJ **5.** 20.39 min

Single Correct Answer Type

6. (c) **7.** (d) **8.** (d) **9.** (c) **10.** (d)
11. (c) **12.** (d) **13.** (c) **14.** (b) **15.** (b)

Multiple Correct Answers Type

16. (b, d) **17.** (a, b, c) **18.** (a, d) **19.** (a, d)
20. (a, c, d)

Matching Column Type

21. (A → 3), (B → 1), (C → 4), (D → 6), (E → 2), (F → 5)

Integer Type

22. (3) **23.** (9)

Comprehension Type

24. (c) **25.** (b) **26.** (b) **27.** (a)

DPP 4.6

Parallel Reaction, Consecutive Reactions, Special Cases of First Order Reactions

Subjective Type

1. An organic compound dissociates into n parallel first order reactions simultaneously and produces n different products $P_1, P_2, P_3, \ldots, P_n$ having rate constants $k, 2k, 3k, \ldots, nk$ and activation energies $E, 2E, 3E, \ldots, nE$ respectively. Calculate the overall energy of activation of the compound P.

2. For a consecutive first order reaction $A \xrightarrow{k_1} B \xrightarrow{k_2} C$, the values of k_1 and k_2 are 45 hr^{-1} and 15 hr^{-1} respectively. If the reaction is carried out with pure A at a concentration of 1.0 mol dm^{-3},
   (a) How much time will be required for the concentration of B to reach a maximum?
   (b) What will be the maximum concentration of B?
   (c) What will be the composition of the reacting system after a time interval of 10 minutes?

3. The formation in water of d-potassium chromo-oxalate from its l-form is reversible reaction which is first order in both directions, the racemate being the equilibrium product. A polarimeter experiment at 22°C showed that, after 560 sec, 12 mole% of the l-isomer was converted to the d-form. Find the rate constant for the forward and the reverse reactions.

4. Derive the O.P. for decomposition of H_2O_2 from the following data.

Time in minute	10	15	20	25	∞
Volume of O_2 given by H_2O_2	6.30	8.95	11.40	13.5	35.75

5. The kinetics of hydrolysis of methyl acetate in excess dilute HCl at 25°C were followed by withdrawing 2 mL of the reaction mixture at intervals of (t), adding 50 mL water and titrating with baryta water. Determine the velocity constant of hydrolysis.

t (in minute)	0	75	119	259	∞
Titre value (in mL)	19.24	24.20	26.60	32.23	42.03

6. In the inversion of cane sugar in presence of an acid, the following polarimeter readings are obtained.

Time in minute	0	30	90	230	∞
Rotation in degree	+ 46.75	+ 41.0	+ 30.75	+ 12.75	−18.75

Calculate the rate constant.

Single Correct Answer Type

7. For a reaction, $A \rightarrow B + C$, it was found that at the end of 10 minutes from the start, the total optical rotation of the system was 50° and when the reaction is complete, it was 100°. Assuming that only B and C are optically active and dextro rotatory. Calculate the rate constant of this first order reaction.
   (a) $k = 0.695\ min^{-1}$ (b) $k = 0.0693\ sec^{-1}$
   (c) $k = 0.0693\ min^{-1}$ (d) $k = 0.00693\ sec^{-1}$

8. For the consecutive unimolecular-type first-order reaction $A \xrightarrow{k_1} R \xrightarrow{k_2} S$, the concentration of component R, C_R at any time t is given by –

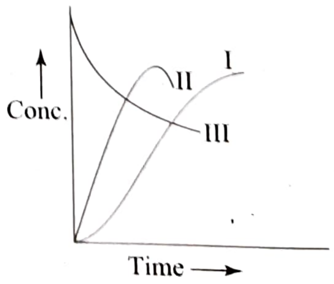
$$C_R = C_{AO} K_1 \left[\frac{e^{-k_1 t}}{(k_2 - k_1)} + \frac{e^{-k_2 t}}{(k_1 - k_2)}\right]$$

if $C_A = C_{AO}$, $C_R = CRO = 0$ at $t = 0$

The time at which the maximum concentration of R occurs is –

   (a) $t_{max} = \dfrac{k_2 - k_1}{\ln(k_2/k_1)}$ (b) $t_{max} = \dfrac{\ln(k_2/k_1)}{k_2 - k_1}$
   (c) $t_{max} = \dfrac{e^{k_2/k_1}}{k_2 - k_1}$ (d) $t_{max} = \dfrac{e^{k_2 - k_1}}{k_2 - k_1}$

9. A first order homogeneous reaction of the type $X \rightarrow Y \rightarrow Z$ (consecutive reaction) is carried out in a CSTR. Which of the following curves respectively show the variation of the concentration of X, Y and Z with time?
   (a) I, II, III (b) III, II, I
   (c) III, I, II (d) II, III, I



10. For the consecutive unimolecular-type first order reaction $A \xrightarrow{k_1} R \xrightarrow{k_2} S$, the concentration of component A, C_A at any time t is given by -

(a) $C_A = C_{A_0} e^{(k_1+k_2)t}$ (b) $C_A = C_{A_0} e^{-(k_1+k_2)t}$

(c) $C_A = C_{A_0} e^{-k_1 t}$ (d) $C_A = C_{A_0} e^{k_1 t}$

11. A substance undergoes first order decomposition. The decomposition follows two parallel first order reactions as:

$$\begin{tikzcd} & B \\ A \arrow[ur, "k_1"] \arrow[dr, "k_2"'] & \\ & C \end{tikzcd}$$

$k_1 = 1.26 \times 10^{-4}\ \text{s}^{-1}$ and
$k_2 = 3.8 \times 10^{-5}\ \text{s}^{-2}$

The percentage distributions of B and C are:

(a) 80% B and 20% C (b) 76.83% B and 23.17% C

(c) 90% B and 10% C (d) 60% B and 40% C

12. Consider the elementary reaction sequence shown in figure. Which of the following equations are correct?

$$\begin{tikzcd} A \arrow[r, "k_1"] \arrow[d, "k_4"'] & B \arrow[d, "k_2"] \\ D & C \arrow[l, "k_3"] \end{tikzcd}$$

(a) $\dfrac{d[A]}{dt} = -k_1[A] + k_4[D]$

(b) $\dfrac{d[C]}{dt} = k_2[B] - k_3[C]$

(c) $\dfrac{d[D]}{dt} = -k_4[D] + k_3[D]$

(d) Nothing can be said about order of reactions in this problem.

13. Acid hydrolysis of ester is first order reaction and rate constant is given by

$$k = \frac{2.303}{t}\log\frac{V_\infty - V_0}{V_\infty - V_t}$$

Where, V_0, V_t and V_∞ are the volume of standard NaOH required to neutralize acid present at a given time, if ester is 50% neutralised then

(a) $V_\infty = V_t$ (b) $V_\infty = (V_t - V_0)$

(c) $V_\infty = 2V_t - V_0$ (d) $V_\infty = 2V_t - V_0$

14. Inversion of sucrose ($C_{12}H_{22}O_{11}$) is first-order reaction and is studied by measuring angle of rotation at different intervals of time

$$\underset{\substack{\text{Sucrose}\\ \text{d}}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\substack{\text{glucose}\\ \text{d}}}{C_6H_{12}O_6} + \underset{\substack{\text{fructose}\\ \text{l}}}{C_6H_{12}O_6}$$

If $(r_\infty - r_0) \equiv a$ and $(r_\infty - r_t) \equiv (a - x)$, (where, r_0, r_t and r_∞ are the angle of rotation at the start, at the time t and at the end of the reaction respectively), then there is 50% inversion when

(a) $r_0 = 2r_t - r_\infty$ (b) $r_0 = r_t - 2r_\infty$

(c) $r_0 = r_t - 2r_\infty$ (d) $r_0 = r_t - r_\infty$

15. Saponification of ethyl acetate ($CH_3COOC_2H_5$) by NaOH is studied by titration of the reaction mixture have 1 : 1 molar ratio of the reactants. If 10 mL of 1 N HCl is required by 5 mL of the solution at the start and min, then rate constant is

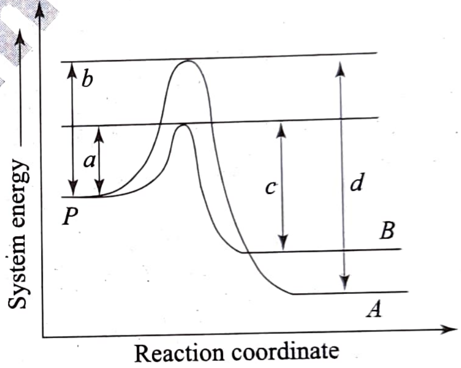
(a) $k = \dfrac{2.303}{10}\log\dfrac{10}{8}$ (b) $k = \dfrac{2.303}{10}\log\dfrac{10}{2}$

(c) $k = \dfrac{1}{10}\left[\dfrac{1}{8} - \dfrac{1}{10}\right]$ (d) $k = \dfrac{1}{10}\left[\dfrac{1}{2} - \dfrac{1}{10}\right]$

Multiple Correct Answers Type

16. Consider the decay of P to A and B by two parallel first order reactions as shown in figure. Given

Reaction	ΔH	Rate constant	Energy of activation
$P \rightarrow A$	ΔH_A	k_A	E_A
$P \rightarrow B$	ΔH_B	k_B	E_B



Which of the following is(are) true?

(a) $a = E_B$ (b) $b = E_A$

(c) $\Delta H_A = b - d$ (d) $\Delta H_B = c - a$

17. Which of the following statements are correct?

(a) Saponification of an ester is a first-order reaction.

(b) Acid hydrolysis of an ester is first-order with respect to H^+ and first order with respect to ester

(c) An elementary step has an order equal to its molecularity

(d) The order of a reaction is never greater than two.

18. In the reversible reaction, $2NO_2 \underset{k_2}{\overset{k_1}{\rightleftharpoons}} N_2O_4$, the rate of disappearance of NO_2 is equal to

(a) $\dfrac{2k_1}{k_2}[NO_2]^2$

(b) $2k_1[NO_2]^2 - 2k_2[N_2O_4]$

(c) $2k_1[NO_2]^2 - k_2[N_2O_4]$

(d) $2k_1\{[NO_2]^2 - \dfrac{k_2}{k_1}[N_2O_4]\}$

19. The rate expression for the reaction :
$NH_4CNO \rightleftharpoons NH_2CONH_2$
can be derived from the mechanism :

(i) $NH_4CNO \underset{k_2}{\overset{k_1}{\rightleftharpoons}} NH_4NCO$ (Fast)

(ii) $NH_4NCO \xrightarrow{k_3} NH_3 + HNCO$ (Fast)

(iii) $NH_4 + HNCO \xrightarrow{k_4} NH_2CONH_2$ (Slow)

Which of the following statements are correct about rate expression?

(a) $\frac{d_{[urea]}}{dt} = \frac{K_1K_3}{K_2}[NH_4NCO]$

(b) $\frac{d_{[urea]}}{dt} = \frac{K_1K_3}{K_2K_4}[NH_4NCO]$

(c) $\frac{d_{[urea]}}{dt} = K[NH_4NCO]$

(d) $\frac{d_{[urea]}}{dt} = \frac{K_1 \times K_2}{K_3 \times K_4}[NH_4NCO]$

20. The rate of formation for $C_6H_6 + 3H_2 \underset{K_2}{\overset{K_1'}{\rightleftharpoons}} C_6H_{12}$ for the forward reaction is first order with respect to C_6H_6 and H_2 each. Which are correct?

(a) $K_c = \frac{K_f}{K_b}$ (b) $K_c = \frac{[C_6H_{12}]}{[C_6H_6][H_2]^3}$

(c) $r_f = K_f[C_6H_6][H_2]$ (d) $r_b = K_b[C_6H_{12}][H_2]^{-2}$

Matching Column Type

21. Match the following:

	Column I		Column II
(a)	Zero-order reaction	(p)	Acid hydrolysis of an ester
(b)	First-order reaction	(q)	Saponification of an ester
(c)	Second-order reaction	(r)	$2NO + Cl_2 \rightarrow 2NOCl$
(d)	Third-order reaction	(s)	Substrate in an enzyme reaction
		(t)	Hydrolysis of cane sugar

Integer Type

22. A reaction occurs in '*n*' parallel paths. For each path having energy of activation as *E*, 2*E*, 3*E*, …, *nE* and rate constant *K*, 2*K*, 3*K*, …, *nK* respectively. If $E_{AV} = 3E$, then *n* is …

23. The half lives of two parallel path reaction $A \begin{cases} \rightarrow B \\ \rightarrow C \end{cases}$ are 4 hrs and 12 hrs respectively. The average half-life for the decay of *A* is …….

Comprehension Type

Frequently a species can react in different ways to give a variety of products. For example, Toluene can be nitrated at the ortho, meta, or para positions, we shall consider the simplest case, that of two competing irreversible first-order reactions:

$$A \xrightarrow{k_1} C \text{ and } A \xrightarrow{k_2} D$$

where the stoichiometric coefficients are taken as unity for simplicity. The rate law is

$$\left(\frac{d[A]}{dt}\right) = -k_1[A] - k_2[A] = -(k_1 + k_2)[A]$$

$$\Rightarrow [A] = [A]_0\, e^{-(k_1+k_2)t}$$

For *C*, we have $\left(\frac{d[C]}{dt}\right) = k_1[A]$

$= k_1[A]_0\, e^{-(k_1+k_2)t}$. Multiplication by *dt* and integration from time 0 (where $[C]_0 = 0$) to an arbitary time *t* gives

$$[C] = \frac{k_1[A]_0}{k_1 + k_2}(1 - e^{-(k_1+k_2)t})$$

Similarly, integration of $\left(\frac{d[D]}{dt}\right)$ gives

$$[D] = \frac{k_2[A]_0}{k_1 + k_2}(1 - e^{-(k_1+k_2)t})$$

The sum of the rate constants $k_1 + k_2$ appears in the exponentials for both [*C*] and [*D*]. Figure shows plots of [*A*], [*C*] and [*D*] versus *t* for $k_1 = 2k_2$.

At any time we also have $\frac{[C]}{[D]} = \frac{k_1}{k_2}$.

24. $A \begin{cases} \xrightarrow{k_1} 2B \\ \xrightarrow{k_2} 3C \end{cases}$ starting initially with only *A*, which of the following is correct at time *t*?

(a) $[A]_0 = [A]_t + [B]_t + [C]_t$

(b) $[A]_0 = [A]_t + 2[B]_t + 3[C]_t$

(c) $[A]_0 = [A]_t + \frac{[B]_t}{2} + \frac{[C]_t}{3}$

(d) $[A]_0 = \frac{2}{3}[A]_t + [B]_t + [C]_t$

25. $X \begin{cases} \xrightarrow{k_1} Y \\ \xrightarrow{k_2} Z \end{cases}$ starting initially with only '*X*', ratio $\frac{[X]_t}{[Y]_t + [Z]_t}$

(a) independent of time

(b) $\frac{1}{(e^{kt} - 1)}$

(c) Depends upon initial concentration of *X*

(d) $[A]_0\,(e^{kt} - 1)$

26. For $A \begin{cases} \xrightarrow{k_1} 3B \\ \xrightarrow{k_2} 4C \end{cases}$ Starting with pure *A* ratio of rate of production of *B* to *C* is:

(a) Independent of time

(b) Independent of temperature

(c) Depends upon initial concentration of *A*

(d) Independent of mechanism of reaction

Answers Key

Single Correct Answer Type

7. (a) **8.** (b) **9.** (b) **10.** (c) **11.** (b)
12. (b) **13.** (c) **14.** (a) **15.** (c)

Multiple Correct Answers Type

16. (a, b, c) **17.** (b, c) **18.** (b, d) **19.** (a, c)
20. (a, b, c, d)

Matching Column Type

21. (a → s), (b → p, t), (c → q), (d → r)

Integer Type

22. (4) **23.** (3)

Comprehension Type

24. (c) **25.** (b) **26.** (a)

5

Surface Chemistry

DPP 5.1

Adsorption

Subjective Type

1. What are the different thermodynamical parameters that illustrate the mechanism of Adsorption?
2. Draw the following graphs. Do mention their slope and intercept, if can be calculated?

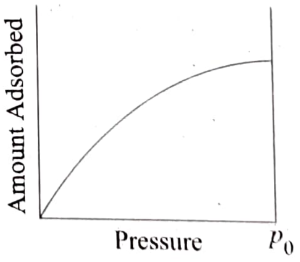
   (a) x/m vs p (b) $\log \frac{x}{m}$ vs $\log p$

   (c) physisorption isobar (d) chemisorption isobar
3. How is adsorption of a gas related to its critical temperature?
4. Give the expression of Freundlich isotherms. How the order vary at different pressures?

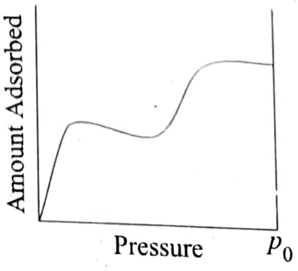
Single Correct Answer Type

5. Chemical adsorption
   - (a) Increase with increase in temperature
   - (b) Decreases with increase in temperature
   - (c) First increases then decreases with increase in temperature
   - (d) First decreases then increases with increase in temperature
6. In Langmuir's model of adsorption of a gas on a solid surface,
   - (a) the rate of dissociation of adsorbed molecules from the surface does not depend on the surface covered.
   - (b) the adsorption at a single site on the surface may involve multiple molecules at the same time.
   - (c) The mass of gas striking a given area of surface is proportional to the pressure of the gas.
   - (d) The mass of gas striking a given area of surface is independent of the pressure of the gas.
7. The most adsorbed gas on an activated charcoal is:
   - (a) N_2 (b) H_2
   - (c) CO_2 (d) CH_4
8. Which is correct in case of van der Waals' adsorption?
   - (a) High temperature, low pressure
   - (b) Low temperature, high pressure
   - (c) Low temperature, low pressure
   - (d) High temperature, high pressure
9. From the following graphs, which two represent Langmuir Adsorption Isotherms?

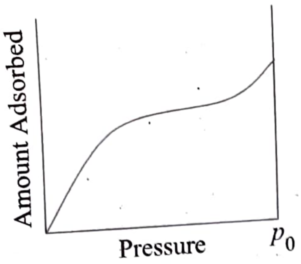
(a)



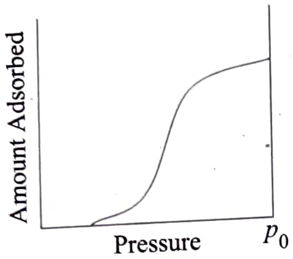
(b)



(c)



(d)



Select the correct option:

(a) A, B
(b) B, C
(c) C, D
(d) A, C

10. Chromatography is a technique based on:

(a) solubilities of solute
(b) adsorption of solute
(c) chemical adsorption followed by dispersion
(d) differential adsorption of different constituents of a mixture.

11. If H_2 gas is made to adsorb on a surface, then the fraction of surface area of adsorbent covered by gas molecules is proportional to

(a) p
(b) p^0
(c) $p^{1/2}$
(d) p^2

12. 2.0 g of charcoal is placed in 100 mL of 0.05 M CH_3COOH to form an adsorbed mono-acidic layer of acetic acid molecules and thereby the molarity of CH_3COOH reduces to 0.49. The surface area of charcoal is 3×10^2 m^2 g^{-1}. The surface area of charcoal adsorbed by each molecule of acetic acid is

(a) 1.0×10^{-18} cm^2
(b) 1.0×10^{-19} cm^2
(c) 1.0×10^{13} cm^2
(d) 1.0×10^{-14} cm^2

Multiple Correct Answers Type

13. Which of the following are related to physical adsorption?

(a) It is reversible in nature
(b) It involves the formation of unimolecular layer
(c) It has low heat of adsorption
(d) It takes place at low temperature and decreases with increase in temperature.

14. Which of the following is/are correct about Freundlich's adsorption isotherm for gases and solutions?

(a) $\frac{x}{m} = kc^{1/n}$

(b) $\frac{x}{m} = \frac{1+bp}{a}$

(c) $\log\frac{x}{m} = \log k + n \log p$

(d) $\log\left(\frac{x}{m}\right) = \log k + \frac{1}{n}\log c$

15. Which statement(s) is/are correct?

(a) Physical adsorption is due to van der Waals' forces
(b) Physical adsorption decreases at high temperature and low pressure
(c) Physical adsorption is reversible
(d) Adsorption energy for a chemical adsorption is generally lesser than that of physical adsorption.

16. Which of the following statements are wrong?

(a) A solid with a rough surface is better adsorbent than the same solid with a smooth surface.
(b) Emulsifiers do not work on the principle of adsorption.
(c) Silica and aluminium gels are used as adsorbents for removing moisture
(d) In adsorption, concentration is same throughout the material.

17. Select the correct statements among the following:

(a) At 83 K, N_2 is physisorped on the surface of iron.
(b) At 772 K and above N_2 is chemisorped on the iron surface.
(c) Activation energy is +ve in case of physisorption and zero in case of chemisorption.
(d) Activation energy is zero in case of physisorption and +ve in case of chemisorption.

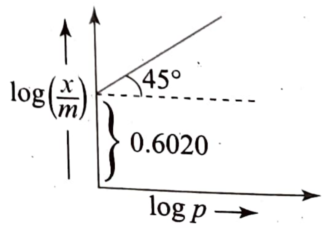
Matching Column Type

18. Match Column I with Column II.

Column I	Column II
(a) Adsorption	(p) Enthalpy of adsorption is quite low
(b) Physisorption	(q) Rate of adsorption decreases as pressure increases
(c) Desorption	(r) Rate remains same throughout the process
(d) Chemisorption	(s) Endothermic in nature.

Integer Type

19. Graph between $\log\left(\frac{x}{m}\right)$ and $\log p$ is straight line at ang of 45° with the intercept of 0.6020.



The extent of adsorption $\left(\frac{x}{m}\right)$ at a pressure of 1 atm is

Comprehension Type

Freundlich adsorption isotherm is obeyed by the adsorptions where the adsorbate forms a multi-molecular layer on the surface of adsorbent. In such case, the degree of adsorption varies linearly with pressure but at high pressure, it becomes independent of pressure.

The relation of Freundlich adsorption isotherm is:

$$\frac{x}{m} = kp^{1/n}$$

where k and n are constants.

Langmuir adsorption isotherm is obeyed by the adsorption where the adsorbate forms only a unimolecular adsorbed layer. The mathematical relation of Langmuir adsorption isotherm is:

$$\frac{x}{m} = \frac{ap}{1+bp}$$

Answer the following questions:

20. For adsorption of a gas on a solid, the plot of log $\left(\frac{x}{m}\right)$ vs log p is linear with slope equal to (n being whole number):

(a) k (b) $\log k$

(c) n (d) $\frac{1}{n}$

21. The equation of Langmuir adsorption isotherm under high pressure is:

(a) $\frac{x}{m} = \frac{a}{b}$ (b) $\frac{x}{m} = ap$

(c) $\frac{x}{m} = \frac{1}{ap}$ (d) $\frac{x}{m} = \frac{b}{a}$

22. Which of the following is a wrong form of Langmuir adsorption isotherm?

(a) $\frac{x}{m} = \frac{a}{b}$ (At high pressure)

(b) $\frac{x}{m} = ap$ (At very low pressure)

(c) $\frac{x}{m} = \frac{b}{a} + \frac{1}{ap}$ (At intermediate pressure)

(d) $\frac{x}{m} = \frac{ap}{b}$ (At high pressure)

Answers Key

Single Correct Answer Type

5. (c) **6.** (c) **7.** (c) **8.** (b) **9.** (d)

10. (d) **11.** (c) **12.** (d)

Multiple Correct Answers Type

13. (a, c, d) **14.** (a, d) **15.** (a, b, c)

16. (b, d) **17.** (a, b, d)

Matching Column Type

18. (a → r), (b → p), (c → s), (d → q)

Integer Type

19. (4)

Comprehension Type

20. (d) **21.** (a) **22.** (a)

DPP 5.2

Colloids (Classification, Preparation, Purification)

Subjective Type

1. "Colloid is not a substance but a state of function." Justify the statement.
2. (a) Explain what is observed when dialysis is prolonged.
   (b) Explain: same substance can act both as colloid and crystalloid.
3. What is colloidion? Where it is used?
4. Lyophilic colloids are reversible sols and Lyophobic colloids are irreversible sols. Why?

Single Correct Answer Type

5. Purple of cassius is:
   (a) Au sol in water (b) Ag sol in water
   (c) Cu sol in water (d) None of these
6. Black diamonds are the dispersion of:
   (a) Solid in solid (b) Solid in gas
   (c) Solid in liquid (d) Liquid in solid
7. Bredig's arc method cannot be used for the preparation of colloidal sol of:
   (a) Copper (b) Gold
   (c) Silver (d) Sodium
8. The colloidal system consisting of a liquid adsorbate in a solid arsorbent in termed as:
   (a) aerosol (b) foam
   (c) emulsion (d) gel
9. The charge on As_2S_3 sol is due to the adsorption of:
   (a) $H^{\oplus}$ (b) $OH^{\ominus}$
   (c) O_2^- (d) S^{2-}
10. A colloidal system involves:
    (a) a state of dissolution (b) a state of dispersion
    (c) a state of suspension (d) none of these
11. Which characteristic is the most important factor in giving rise to peculiar properties of colloids?
    (a) Large size
    (b) Small size
    (c) High charge density
    (d) High ratio of surface area to the volume

Multiple Correct Answers Type

12. At CMC, the surfactant molecules undergo:
    (a) ionization
    (b) aggregation
    (c) micelle formation
    (d) reduction in the surface tension of water
13. Colloidal gold can be prepared by:
    (a) reduction of $AuCl_3$ (b) Bredig's arc method
    (c) hydrolysis (d) peptization
14. Select the correct statements among the following:
    (a) Foam is a colloidal solution of gas in liquid
    (b) Aerosol is a colloidal solution of liquid in gas
    (c) Gel is a colloidal solution of solid in liquid
    (d) Emulsion is a colloidal solution of liquid in liquid.
15. Which of the following statements are correct regarding mechanical disintegration?
    (a) This method comprises both dispersion and condensation
    (b) This method is not used for the preparation of colloidal graphite and printing ink.
    (c) This method is suitable when dispersion medium is an organic liquid.
    (d) A stabilizer is often added to stabilize the colloidal solution.
16. Which among the following are lyophilic in nature?
    (a) Starch (b) Gum
    (c) Gelatin (d) Gold

Matching Column Type

17. Match Column I with Column II.

Column I	Column II
(a) Mist	(p) Jellies
(b) Rain cloud	(q) Whipped cream
(c) Gel	(r) Aerosol
(d) Foam	(s) Solid or liquid dispersed in air

Comprehension Type

There are certain substances which behave as normal, strong electrolytes at low concentration but at higher concentration they behave as colloidal solutions due to the formation of aggregated particles. Such colloids are called associated colloids and the aggregated particles are called micelles. Soaps and detergents are the examples of associated colloids. The formation of micelles takes place above certain concentration called critical micellization concentration (CMC) and a characteristic temperature.

18. Micelles are
(a) emulsions cum gels (b) associated colloids
(c) adsorbed catalysts (d) ideal solutions

19. What type of molecules form micelles?
(a) Non-polar molecules
(b) Polar molecules
(c) Surfactant molecules
(d) Salt of weak acid and weak base

20. Micelles are formed only:
(a) below the CMC and the Kraft temperature
(b) above the CMC and below the Kraft temperature
(c) above the CMC and above the Kraft temperature
(d) below the CMC and above the Kraft temperature.

21. Above CMC, the surfactant molecules undergo:
(a) dissociation (b) aggregation
(c) micelle formation (d) all of these

22. Micelles are used in:
(a) detergents (b) magnetic separation
(c) petroleum recovery (d) all of these

Answers Key

Single Correct Answer Type

5. (a) **6.** (a) **7.** (d) **8.** (d) **9.** (d)
10. (b) **11.** (d)

Multiple Correct Answers Type

12. (b, c, d) **13.** (a, b) **14.** (a, b, d)
15. (b, c) **16.** (a, b, c)

Matching Column Type

17. (a → r, s), (b → r, s), (c → p), (d → q)

Comprehension Type

18. (b) **19.** (c) **20.** (c) **21.** (b, c) **22.** (a, c)

DPP 5.3

Colloids (Properties, Coagulation, Protection, Emulsions and Applications)

Subjective Type

1. On the basis of Hardy-Schulze rule, explain why the coagulating power of phosphate is higher than chloride?
2. Gelatin which is a peptide is added in ice-creams. What can be its role?
3. How one can distinguish between oil-in-water-type and water-in-oil type emulsion?
4. Why is it essential to wash the precipitate with water before estimating it quantitatively?

Single Correct Answer Type

5. Which of the following mixture will lead to the formation of negatively charged colloid $[AgI]I^{\ominus}$?
   (a) 50 ml of 0.1 M $AgNO_3$ + 50 ml of 0.1 M KI
   (b) 50 ml of 0.1 M $AgNO_3$ + 50 ml of 0.2 M KI
   (c) 50 ml of 0.2 M $AgNO_3$ + 50 ml of 0.1 M KI
   (d) 50 ml of 0.2 M $AgNO_3$ + 50 ml of 0.2 M KI
6. The Brownian motion is due to:
   (a) Temperature fluctuations within the liquid phase
   (b) Attraction and repulsion between charges on the colloidal particles
   (c) Impact of the molecules of the dispersion medium on the colloidal particles.
7. Gold number of few colloids are given below,
   Gelatin = 0.005 Starch = 25
   Egg albumin = 0.08 Gum Arabic = 0.10
   Which is the best protective colloid?
   (a) Gelatin (b) Starch
   (c) Egg albumin (d) Gum Arabic
8. Blood contains:
   (a) +vely charged particles
   (b) −vely charged particles
   (c) Neutral particles
   (d) −vely as well as +vely charged particles.
9. Isoelectric point refers to the $H^{\oplus}$ ion concentration at which the colloidal particles:
   (a) coagulate
   (b) become electrically neutral
   (c) can move to either electrode when subjected to an electric field
   (d) reverse their electrical charge.
10. Which of the following has least flocculating value of positive sol?
    (a) $Cl^{\ominus}$ (b) SO_4^{2-}
    (c) PO_4^{3-} (d) $[Fe(CN)_6]^{4-}$
11. Which is correct?
    (a) Brownian movement is more pronounced for small particles than the bigger ones.
    (b) Sols of metal sulphides are lyophilic.
    (c) Hardy–Schulze law states that larger the size of the coagulation ion greater is its coagulation power.
    (d) A lyophilic sol is most stable at isoelectric point.
12. The coagulation of 100 mL of colloidal solution of gold is completely prevented by addition of 0.25 g of a substance "X" to it before addition of 1 mL of 10% NaCl solution. The gold number of "X" is:
    (a) 0.25 (b) 25
    (c) 250 (d) 2.5

Multiple Correct Answers Type

13. Which of the following statements are correct?
    (a) Mixing two oppositely charged sols neutralizes their charges and stabilizes the colloid
    (b) Presence of equal and similar charges on colloidal particles provides stability to the colloids
    (c) Any amount of dispersed liquid can be added to emulsion without destabilizing it
    (d) Brownian movement stabilizes sols
14. Which of the following substances will precipitate the negatively charged emulsions?
    (a) KCl (b) Glucose
    (c) Urea (d) NaCl
15. Which of the following are the properties of colloidal sols?
    (a) Tyndall effect (b) Brownian movement
    (c) Maxwell distribution (d) Electrophoresis
16. Which of the following processes can destroy the emulsion?
    (a) Freezing

(b) By electrophoresis at high potential
(c) Hydrolysis
(d) Peptization

17. Which of the following statements are true?
(a) Flocculation value is inversely proportional to coagulating power
(b) Colloidal silica is protective colloid
(c) Alum is used for cleaning muddy water
(d) Gelatin is added in ice cream, it acts as an emulsifier.

Matching Column Type

18. Match Column I with Column II.

Column I	Column II
(a) Precipitation of colloidal sol	(p) Peptization
(b) Purification	(q) Coagulation
(c) Gold number	(r) Measure of protective power
(d) Formation of sol	(s) Dialysis

Comprehension Type

The minimum concentration of the electrolyte in millimoles per litre of the solution, required to cause coagulation of a particular sol is called coagulation value or flocculation value of the electrolyte for the sol. The ions carrying opposite charge to that of sol particles are effective in causing coagulation of the sol. Coagulating power of an electrolyte is directly proportional to the valency of the active ions i.e., ions causing coagulation. Coagulation or flocculation is the precipitation of a colloid through induced aggregate of its particles. There are several methods for coagulation of colloidal solution like by repeated dialysis, by adding electrolyte, by electrophoresis, etc.

Answer the following questions:

19. Which of the following will have highest coagulating power for As_2S_3 colloid?
(a) Al^{3+}
(b) Na^+
(c) SO_4^{2-}
(d) PO_4^{3-}

20. In the coagulation of positive sol, the flocculation power of Cl^-, SO_4^{2-}, PO_4^{3-}, $[Fe(CN)_6]^{4-}$ are in the order of:
(a) $Cl^- > SO_4^{2-} > PO_4^{3-} > [Fe(CN)_6]^{4-}$
(b) $[Fe(CN)_6]^{4-} > PO_4^{3-} > SO_4^{2-} > Cl^-$
(c) $Cl^- > PO_4^{3-} > SO_4^{2-} > [Fe(CN)_6]^{4-}$
(d) $Cl^- > SO_4^{2-} > [Fe(CN)_6]^{4-} > PO_4^{3-}$

21. Flocculating value of ion depends on:
(a) the shape of flocculating ion
(b) the amount of flocculating ion
(c) nature of the charge on the flocculating ion
(d) both, the nature and magnitude of the charge of the flocculating ion

22. 1 mol of $[AgI]\,Ag^+$ can be coagulated by:
(a) 1 mol of $AgNO_3$
(b) 1/2 mol of $AgNO_3$
(c) 2/3 mol of $AgNO_3$
(d) none of these

Answers Key

Single Correct Answer Type

5. (b) **6.** (c) **7.** (a) **8.** (b) **9.** (b)
10. (d) **11.** (a) **12.** (b)

Multiple Correct Answers Type

13. (b, d) **14.** (a, d) **15.** (a, b, d)
16. (a, b) **17.** (a, c, d)

Matching Column Type

18. (a → q), (b → s), (c → r), (d → p)

Comprehension Type

19. (a) **20.** (b) **21.** (d) **22.** (d)

DPP 5.4

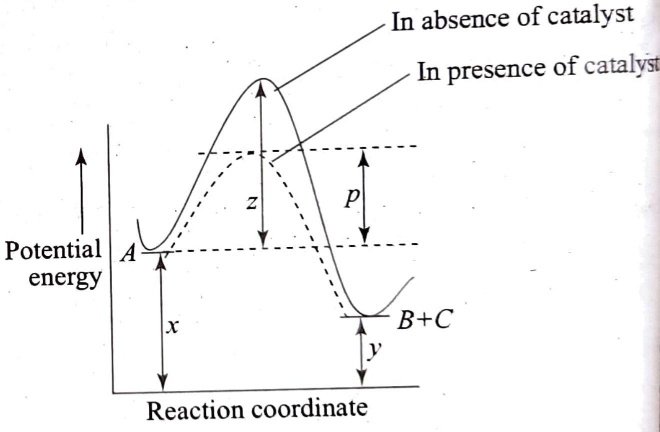
Catalysis

Subjective Type

1. Why is desorption important for a substance to act as good catalyst?
2. What is the role of diffusion in heterogeneous catalyst?
3. How does a solid catalyst enhance the rate of combination of gaseous molecules?
4. What do you understand by shape selective catalysis? Why are zeolites good shape selective catalysts?

Single Correct Answer Type

5. Which of the following process does not occur at the interface of phases?
   (a) Crystallisation
   (b) Heterogeneous catalysis
   (c) Homogeneous catalysis
   (d) Corrosion
6. In which of the following reactions heterogeneous catalysis is involved?
   (i) $2SO_2(g) + O_2(g) \xrightarrow{NO(g)} 2SO_3(g)$
   (ii) $2SO_2(g) \xrightarrow{Pt(s)} 2SO_3(g)$
   (iii) $N_2(g) + 3H_2(g) \xrightarrow{Fe(s)} 2NH_3(g)$
   (iv) $CH_3COOCH_3(l) + H_2O(l) \xrightarrow{HCl(l)} CH_3COOH(aq) + CH_3OH(aq)$
   (a) (ii), (iii)
   (b) (ii), (iii) and (iv)
   (c) (i), (ii) and (iii)
   (d) (iv)
7. Hydrolysis of protein in stomach and in intestine takes place due to action of enzyme:
   (a) pepsin in stomach, trypsin in intestine
   (b) trypsin in stomach, pepsin in intestine
   (c) both (a) and (b)
   (d) none of the above
8. Which acts as negative catalyst?
   (a) A catalyst remains unchanged chemically at the end of chemical reaction
   (b) A catalyst takes part in a chemical reaction
   (c) All kinds of catalysts undergo catalytic poisoning
   (d) A catalyst physically changes at the end of reaction.
9. The rate of a certain biochemical reaction catalysed by an enzyme in human body is 10^4 times faster than when it carried out in the laboratory. The activation energy of this reaction:
   (a) is zero
   (b) is different in two cases
   (c) is the same in both the cases
   (d) none of the above
10. Air can oxidize sodium sulphite in aqueous solution but cannot do so in the case of sodium arsenite. If however, air is passed through a solution containing both sodium sulphite and sodium arsenite then both are oxidized. This is an example of:
    (a) positive catalysis
    (b) negative catalysis
    (c) induced catalysis
    (d) auto-catalysis
11. ZSM-5 is used to convert:
    (a) alcohol to petrol
    (b) benzene to toluene
    (c) toluene to benzene
    (d) heptane to toluene
12. For the reaction A → B + C; the energy profile diagram is given in the figure:



What is the decrease in energy of activation in presence o catalyst?
    (a) z
    (b) $z - p$
    (c) $y - z$
    (d) $z - x$

Multiple Correct Answers Type

13. Which of the following statements are correct about soli catalyst?
    (a) Same reactants may give different products by using different catalysts
    (b) Catalyst does not change ΔH of reaction
    (c) Catalyst is required in large quantities to catalys reaction
    (d) Catalytic activity of a solid catalyst does not depen upon the strength of chemisorption.

14. In a reaction, catalyst changes....
   (a) physically (b) qualitatively
   (c) chemically (d) quantitatively

15. Which act(s) as negative catalyst?
   (a) Lead tetraethyl as antiknock compound
   (b) Glycerol in decomposition of H_2O_2
   (c) Ethanol in oxidation of chloroform
   (d) None of the above

16. Which of the following statements is/are true?
   (a) Iron is used as a catalyst in the hydrogenation of oils
   (b) V_2O_5 is used as a catalyst in the oxidation of SO_2 to SO_3
   (c) Haber's process requires iron as a catalyst
   (d) Thermite process does not involve any catalyst

17. Which of the following statements is/are true for heterogeneous catalysis?
   (a) The energy of activation does not change
   (b) The catalyst combines with the reactant to form a compound
   (c) The reactant molecules are adsorbed on the surface of the catalyst
   (d) The catalyst lowers the energy of activation.

Matching Column Type

18. Match Column I with Column II.

Column I	Column II
(a) $BaSO_4$	(p) Inhibitor for decomposition of H_2O_2
(b) Acetamide	(q) Catalyst
(c) Zeolite	(r) Removes hardness of water
(d) Nickel	(s) Poison for Pd in Lindlar's catalyst

Comprehension Type

Catalysts are the substances which influence the rate of reaction without being consumed. The catalyst may be positive or negative, depending whether they can increase or decrease the rate of reaction. Catalysts alter the mechanism of reaction thereby changing the activation energy. Catalyst poisons decrease or stop the activity of a catalyst, while promoters increase the activity of catalyst. There are some reactions in which one of the products acts as catalyst, called autocatalyst.

Answer the following questions:

19. The decomposition of H_2O_2, is slowed down by the addition of small amount of acetamide. Acetamide acts as:
   (a) promoter
   (b) stopper
   (c) inhibitor
   (d) poison

20. Catalyst can alter:
   (a) the amount of product
   (b) heat of reaction
   (c) rate constant
   (d) equilibrium constant

21. The oxidation of oxalic acid by acidified $KMnO_4$ becomes faster with the passage of time due to:
   (a) presence of H^+ ions
   (b) autocatalysis by Mn^{2+}
   (c) presence of MnO_4^- ions
   (d) presence of K^+ ions

22. In case of autocatalysis:
   (a) product acts as catalyst
   (b) reactant acts as catalyst
   (c) solvent acts as catalyst
   (d) heat produced in the reaction catalysis.

Answers Key

Single Correct Answer Type

5. (c) **6.** (a) **7.** (a) **8.** (d) **9.** (b)
10. (c) **11.** (a) **12.** (b)

Multiple Correct Answers Type

13. (a, b) **14.** (a, b) **15.** (a, b, c)
16. (b, c, d) **17.** (b, c, d)

Matching Column Type

18. (a → s), (b → p), (c → q, r), (d → q)

Comprehension Type

19. (c) **20.** (c) **21.** (b) **22.** (a)

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(a) physically
(b) qualitatively
(c) chemically
(d) quantitatively

15. Which act(s) as negative catalyst?
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Comprehension Type

Catalysts are the substances which influence the rate of reaction without being consumed. The catalyst may be positive or negative, depending whether they can increase or decrease the rate of reaction. Catalysts alter the mechanism of reaction thereby changing the activation energy. Catalyst poisons decrease or stop the activity of a catalyst, while promoters increase the activity of catalyst. There are some reactions in which one of the products acts as catalyst, called autocatalyst.

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(d) equilibrium constant

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(b) autocatalysis by Mn^{2+}
(c) presence of MnO_4^- ions
(d) presence of K^+ ions

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(b) reactant acts as catalyst
(c) solvent acts as catalyst
(d) heat produced in the reaction catalysis.

Answers Key

Single Correct Answer Type

5. (c) **6.** (a) **7.** (a) **8.** (d) **9.** (b)
10. (c) **11.** (a) **12.** (b)

Multiple Correct Answers Type

13. (a, b) **14.** (a, b) **15.** (a, b, c)
16. (b, c, d) **17.** (b, c, d)

Matching Column Type

18. (a → s), (b → p), (c → q, r), (d → q)

Comprehension Type

19. (c) **20.** (c) **21.** (b) **22.** (a)

CHAPTER

6

Nuclear Chemistry

DPP 6.1

Nature of Radioactive Radiations, Group Displacement Law

Subjective Type

1. How many moles of helium are produced when one mole of $^{238}_{92}U$ disintegrates into $^{206}_{82}Pb$?
2. $^{238}_{92}U$ is a natural α-emitter. After α-emission, the residual nucleus U_{X_1} in turns emits a β-particle to produce another nucleus U_{X_2}. Find out the atomic number and mass number of U_{X_1} and U_{X_2}. Also if uranium belongs to IIIrd group, to which group U_{X_1} and U_{X_2} belong?
3. Which one(s) of the following processes – alpha emission, beta emission, positron emission, electron capture – cause (a) an increase in atomic number, (b) a decrease in atomic number, (c) emission of an X-ray in every case?
4. (i) Classify each of the following nuclides as "probably stable," "beta emitter," or "positron emitter": $^{49}_{20}Ca$, $^{195}_{80}Hg$, $^{208}_{82}Pb$, $^{8}_{5}B$, $^{150}_{67}Ho$, $^{30}_{13}Al$, $^{120}_{50}Sn$, $^{94}_{36}Kr$

   (ii) Of the three isobars $^{114}_{48}Cd$, $^{114}_{49}In$ and $^{114}_{50}Sn$, which is likely to be radioactive? Explain your choice.

Single Correct Answer Type

5. Which of the following has a negative charge?
   (a) Neutrino (b) Neutron
   (c) Positron (d) Antiproton
6. One Becquerel of radioactivity is equal to
   (a) one disintegration/s
   (b) two disintegrations/s
   (c) 6.023×10^{23} disintegrations/s
   (d) three disintegrations/s
7. During the transformation of $^{a}_{c}X$ to $^{b}_{d}Y$, the number of β-particles emitted are
   (a) $\frac{a-b}{4}$ (b) $d+\frac{a-b}{2}+c$
   (c) $d+\left(\frac{a-b}{2}\right)-c$ (d) $2c-d+a-b$
8. A radioactive nuclide emits γ-rays due to:
   (a) K-electron capture
   (b) nuclear transition from higher to lower energy state
   (c) presence of greater number of neutrons than protons
   (d) presence of greater number of protons than neutrons
9. In the radioactive decay:
$$^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y \rightarrow {}^{A-4}_{Z-1}Z \rightarrow {}^{A-4}_{Z-1}Z^{*}$$
   the sequence of emission is:
   (a) α, β, γ (b) β, α, γ (c) γ, α, β (d) β, γ, α
10. Which of the following elements is an isodiaphere of $^{235}_{92}U$?
   (a) $^{209}_{83}Bi$ (b) $^{212}_{82}Pb$
   (c) $^{231}_{90}Th$ (d) $^{231}_{91}Pa$

11. A certain radioactive material $^{A}_{Z}X$ starts emitting α and β particles successively such that the end product is $^{A-8}_{Z-3}Y$. The number of α and β particles emitted are:
(a) 4 and 3 respectively (b) 2 and 1 respectively
(c) 3 and 4 respectively (d) 3 and 8 respectively

Multiple Correct Answers Type

12. $^{238}_{92}U$ (III B) undergoes follows emissions

$$^{238}_{92}U \xrightarrow{-\alpha} A \xrightarrow{-\alpha} B \xrightarrow{-\beta} C$$

Which is/are correct statements?
(a) A will be I B group
(b) A will be III B group
(c) B will be of II A (alkaline earth metal) group
(d) C will be of III A (boron family group)

13. In which of the following nuclear process, the electrically neutral atom remains electrically neutral?
(a) α-decay (b) β-decay
(c) γ-decay (d) K-electron capture

14. Which of following options are incorrect regarding the elimination of α and β particles to form an isodiaphere?
(a) $n\alpha$, $n\beta$ (b) $n\alpha$, $(n + 1)\beta$
(c) $n\alpha$ (d) $n\beta$

15. A nuclide has mass number (A) and atomic number (Z). During a radioactive process if:
(1) both A and Z decrease, the process is called α-decay.
(2) A remains unchanged and Z decreases by one, the process is called β^+ or position decay or K-electron capture.
(3) both A and Z remain unchanged, the process is called γ-decay.
(4) both A and Z increase, the process is called nuclear isomerism.
Which of the answers are incorrect?
(a) 1, 2 and 3 (b) 2, 3 and 4
(c) 1, 3 and 4 (d) 1, 2 and 4

16. In the decay process:

$$A \xrightarrow{-\alpha} B \xrightarrow{-\alpha} C \xrightarrow{-\beta} D$$

(1) A and B are isobars
(2) A and D are isotopes
(3) C and D are isobars
(4) A and C are isotones
The incorrect answer is/are:
(a) 1 and 2 (b) 2 and 3
(c) 3 and 4 (d) 1 and 4

Matching Column Type

17. Match the Column I with Column II:

	Column I		Column II
(a)	α-emission	(p)	Mass number changes
(b)	β-emission	(q)	Atomic number and mass number are unaffected
(c)	γ-emission	(r)	Atomic number decreases
(d)	β^+-emission	(s)	Atomic number increases

Integer Type

18. $^{234}_{90}Th$ disintegrates to give $^{206}_{82}Pb$ as the final product. How many beta particles are emitted in this process?

19. An atom has atomic mass 232 and atomic number 90. During the course of disintegration, it emits 2β-particles and few α-particles. The resultant atom has atomic mass 212 and atomic number 82. How many α-particles are emitted during this process?

Comprehension Type

A radioactive nuclide having $n/p > 1.0$ undergoes α-decay, β-decay successively. The parent element on α-decay looses its atomic no. by two units and mass no. by four units. In β-decay the parent gains its atomic no. by one unit whereas mass number remains the same. The γ-emission occurs only when daughter element possesses some higher energy than required for its stability.

20. An element $^{234}_{90}Th$ looses an α-particle. If Th belongs to group III, the daughter element belongs to:
(a) Group I (b) Group II
(c) Group III (d) zero group

21. If atomic mass of Th is 232.18 and its atomic no. is 90. If it looses 6 – α and 4 – β particles, the mass no. of finally stable element is:
(a) 208.18 (b) 208 (c) 226 (d) 212

22. In the nuclear decay of an element (Z = 88, electron = 88, neutron = 145) emitting out $^{4}_{2}He$ nuclei (an α-particle), the number of proton, electron and neutrons in daughter element is:
(a) 86, 88, 143 (b) 86, 86, 143
(c) 86, 88, 144 (d) 86, 86, 142

23. In the nuclear reaction $\overset{60m}{Co} \to \overset{60}{Co}$, the emission occurs as:
(a) X-rays (b) γ-rays
(c) α-particle (d) K-electron capture

Answers Key

Single Correct Answer Type

5. (d) 6. (a) 7. (c) 8. (b) 9. (b)
10. (c) 11. (b)

Multiple Correct Answers Type

12. (b, c) 13. (c, d)
14. (a, b, d) 15. (b, c, d)
16. (a, c, d)

Matching Column Type

17. (a → p, r), (b → s), (c → q), (d → r)

Integer Type

18. (6) 19. (5)

Comprehension Type

20. (b) 21. (b) 22. (b) 23. (b)

DPP 6.2

n/p Ratio, Radioactive Disintegration Series, Nuclear Binding Energy and Packing Fraction

Subjective Type

1. Calculate the energy change for each of the following three types of decay.

   (a) ${}^{40}_{19}K \rightarrow {}^{40}_{20}Ca + {}^{0}_{-1}e$ (b) ${}^{40}_{19}K + {}^{0}_{-1}e \rightarrow {}^{40}_{18}Ar$ and

   (c) ${}^{40}_{19}K \rightarrow {}^{40}_{18}Ar + {}^{0}_{+1}e$

   Given: Atomic masses of ${}^{40}K$, ${}^{40}Ar$ and ${}^{40}Ca$ are 39.964008, 39.962384 and 39.962589 amu, respectively, and that the mass of an electron is 0.0005486 amu. Take 1 amu = 931 MeV.

2. When a ${}^{238}U$ nucleus disintegrates spontaneously, it forms a ${}^{234}Th$ nucleus and an α particle (${}^{4}He$ nucleus). Explain why the change in rest mass during this process can be calculated by subtracting the mass of a ${}^{234}Th$ atom plus the mass of a ${}^{4}He$ atom and the mass of the ${}^{238}U$ atom.

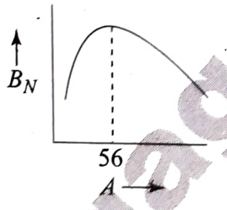
3. Calculate the maximum kinetic energy of the β^- emitted in the radioactive decay of ${}^{6}He$. Assume that the β^- has its maximum energy when no other emission accompanies the process.

4. Consider the two nuclides of mass number 7, ${}^{7}Li$ and ${}^{7}Be$. Which of the two is more stable? How does the unstable nuclide decay into the stable one?

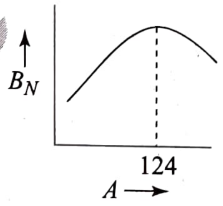
Single Correct Answer Type

5. The dependence of binding energy per nucleon, B_N, on the mass number A is represented by:

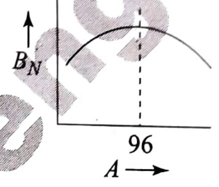
(a)



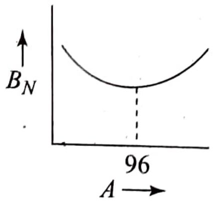
(b)



(c)



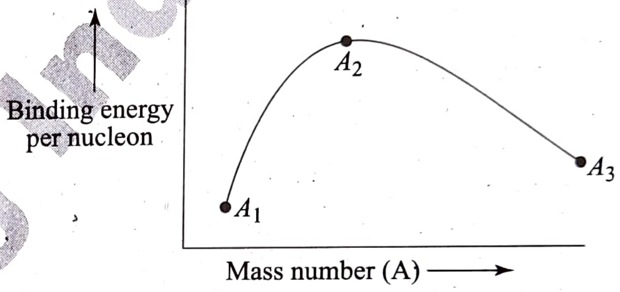
(d)



6. The mass defect for the formation of ${}^{12}C$ is 0.10242 amu. Its binding energy would be
   (a) 95.35 MeV (b) 9.535 MeV
   (c) 95.35 eV (d) 9.535 eV

7. Thorium series starts from ${}^{232}_{90}Th$. If there are emission of six α and four β particles, the end products is
   (a) ${}^{209}_{83}Bi$ (b) ${}^{206}_{82}Pb$ (c) ${}^{208}_{82}Pb$ (d) ${}^{206}_{93}Np$

8. In the following graph, binding energy per nucleon is plotted against mass number (A). Three elements A_1, A_2 and A_3 are located in the graph. Select the false statement about the graph.

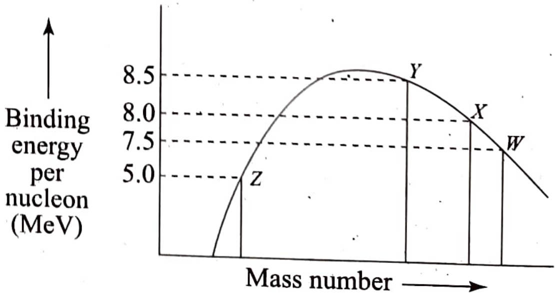


   (a) element A_2 is more stable than A_1
   (b) element A_3 is less stable than A_2
   (c) element A_1 is more stable than both A_2 and A_3
   (d) A_2 is metallic element

9. The binding energy per nucleon of ${}^{16}O$ is 7.97 MeV and that of ${}^{17}O$ is 7.75 MeV. The energy in MeV required to remove a neutron from ${}^{17}O$ is
   (a) 3.52 (b) 3.64
   (c) 4.23 (d) 7.86

10. Which of the following series involves the emission of eight α and five β particles?
   (a) $4n$ series (b) $4n + 1$ series
   (c) $4n + 2$ series (d) $4n + 3$ series

11. Binding energy per nucleon *versus* mass number for W, X, Y, Z are indicated on the curve.



   The process that would release energy is :
   (a) $Y \rightarrow 2Z$ (b) $W \rightarrow X + Z$
   (c) $W \rightarrow 2Y$ (d) $X \rightarrow Y + Z$

Multiple Correct Answers Type

12. ${}^{219}_{86}\text{Rn}$ is a member of actinium series. Which of the following nuclide belong to the same series?

(a) ${}^{235}_{91}\text{Pa}$ (b) ${}^{232}_{90}\text{Th}$

(c) ${}^{235}_{92}\text{U}$ (d) ${}^{227}_{88}\text{Ra}$

13. The disintegration series involving emission of 8α and 6β particles are

(a) $4n$ series (b) $4n + 1$ series

(c) $4n + 2$ series (d) $4n + 3$ series

14. Which of the following elements have binding energy per nucleon less than 7?

(a) ${}^{6}_{3}\text{Li}$ (b) ${}^{12}_{6}\text{C}$

(c) ${}^{10}_{5}\text{B}$ (d) ${}^{56}_{26}\text{Fe}$

15. The mass defect of the nuclear reaction ${}_5\text{B}^8 \rightarrow {}_4\text{Be}^8 + {}_1e^0$ is Δm, the wrong expression is/are

(a) Δm = atomic mass of $({}_4\text{Be}^8 - {}_5\text{B}^8)$

(b) Δm = atomic mass of $({}_4\text{Be}^8 - {}_5\text{B}^8)$ + mass of one electron

(c) Δm = atomic mass of $({}_4\text{Be}^8 - {}_5\text{B}^8)$ + mass of one positron

(d) Δm = atomic mass of $({}_4\text{Be}^8 - {}_5\text{B}^8)$ + mass of two electrons

16. Mass of 1 amu gives energy equal to

(a) 9×10^{13} J (b) 931.5 MeV

(c) 1.494×10^{-10} J (d) 9×10^{6} ergs

Matching Column Type

17. Match the Column I with Column II.

Column I	Column II
(a) ${}^{226}_{88}\text{Ra}$	(p) α-emitter
(b) ${}^{212}_{84}\text{Po}$	(q) $(4n + 2)$ series
(c) ${}^{238}_{92}\text{U}$	(r) β-emitter
(d) ${}^{238}_{81}\text{Th}$	(s) $(4n + 1)$ series

Integer Type

18. The observed mass of ${}^{56}_{26}\text{Fe}$ is 55.9615 amu. Taking the masses of proton and neutron as 1.00737 amu and 1.00866 amu, respectively, calculate the binding energy per nucleon of Fe atom. Take 1 amu = 931 MeV.

19. The binding energy of an element is 63 MeV. If B.E/nucleon is 7, the number of nucleons are....

Comprehension Type

Nuclear binding energy is the energy released during the hypothetical formation of the nucleus by the condensation of individual nucleon. Thus,

$$\text{Binding energy per nucleons} = \frac{\text{Total binding energy}}{\text{Number of nucleons}}$$

For example, the mass of hydrogen atom is equal to the sum of the masses of a proton and an electron. For other atoms, the atomic mass is less the sum of the masses of protons, neutrons and electrons present. This difference in mass, termed as mass defect, is measure of the binding energy of protons and neutrons in the nucleus. The mass–energy relationship postulate *d* by Einstein is expressed as:

$$\Delta E = \Delta mc^2$$

where ΔE is the energy liberated, Δm is the loss of mass, and c is the speed of light.

20. If M_p and M_n are masses of proton and neutron respectively. For a nucleus it binding energy is B and it contains Z protons and N neutrons, the correct relation for this nucleus if C is velocity of light is:

(a) $M(N, Z) = NM_n + ZM_p - BC^2$

(b) $M(N, Z) = NM_n + ZM_p + BC^2$

(c) $M(N, Z) = NM_n + ZM_p - \frac{B}{C^2}$

(d) $M(N, Z) = NM_n + ZM_p + \frac{B}{C^2}$

21. In the reaction ${}^{2}_{1}\text{H} + {}^{3}_{1}\text{H} \rightarrow {}^{4}_{2}\text{He} + {}^{1}_{0}n$, if binding energies of ${}^{2}_{1}\text{H}$, ${}^{3}_{1}\text{H}$ and ${}^{4}_{2}\text{He}$ are respectively a, b, and c (in MeV), then the energy released in this reaction is:

(a) $a + b + c$ (b) $a + b - c$

(c) $c - (a + b)$ (d) $c + a - b$

22. How much heat would be developed per hour from 1 curie of C^{14} source if all the energy of beta decay were imprisoned? Atomic masses of C^{14} and N^{14} are 14.00324 and 14.00307 amu respectively.

(a) 3.36 J (b) 3.37 J

(c) 3.38 J (d) 3.39 J

Answers Key

Single Correct Answer Type

5. (a) **6.** (a) **7.** (c) **8.** (c) **9.** (c)
10. (b) **11.** (c)

Multiple Correct Answers Type

12. (a, d) **13.** (c, d)
14. (a, c) **15.** (a, b, c)
16. (b, c)

Matching Column Type

17. (a → p, q), (b → q, r), (c → p, r), (d → s)

Integer Type

18. (8) **19.** (9)

Comprehension Type

20. (c) **21.** (c) **22.** (b)

DPP 6.3

Rate of Disintegration, Half Life Period, Average Life and Radioactive Equilibrium

Subjective Type

1. The nucleidic ratio, ^3_1H to ^1_1H in a sample of water is $8.0 \times 10^{-18} : 1$. Tritium undergoes decay with a half life period of 12.3 years. How many tritium atoms would 10.0 g of such a sample contain 40 years after the original sample is collected?
2. $_{64}Cu$ (half-life = 12.8 h) decays by β^- emission (38%), β^+ emission (19%) and electron capture (43%). Write the decay products and calculate partial half-life for each of the decay processes.
3. A sample of $^{90}_{38}Sr$ originally had an activity of 0.500 mCi.
   (a) What is the specific activity of the sample?
   (b) What is the activity of the sample after 30.0 y?
4. The half-life of ^{40}K is 1.28×10^9 y. What mass of this nuclide has an activity of 1.00 μCi?

Single Correct Answer Type

5. The half-life of $^{24}_{11}Na$ is 15.0 h. What percentage of it remains after 60 h?
   (a) 0.00% (b) 3.13%
   (c) 6.25% (d) 12.5%
6. For two different disintegration half-lives are equal at equilibrium. This is only when
   (a) $N_1 = N_2$ (b) $\lambda_1 = \lambda_2$
   (c) $(T_{75})_1 = (T_{75})_2$ (d) All of these
7. $$\underset{N_A}{A} \xrightarrow{T_{50} = 100\text{ min}} \underset{N_B}{B} \xrightarrow{T_{75} = 100\text{ min}} C$$
   At equilibrium N_A/N_B is
   (a) 1 (b) 2 (c) 0.5 (d) 20
8. In uranium mineral, the atomic ratio N_{U-238}/N_{Pb-206} is nearly equal to one. The age (in years) of the mineral is nearly (half-life period of U-238 is 4.5×10^9 yr)
   (a) 3.0×10^8 (b) 4.5×10^9
   (c) 3.0×10^9 (d) 4.5×10^8
9. There are 0.618 μg of ^{206}Pb and 0.238 μg of ^{238}U in a rock. If T_{50} of ^{238}U is 1.5×10^9 yr, age of the rock is
   (a) 1.5×10^9 yr (b) 3.0×10^9 yr
   (c) 4.5×10^9 yr (d) 0.75×10^9 yr
10. Tritium, ^3_1H has a half-life of 12.26 yr. A 5.00 mL sample of tritiated water has an activity of 2.40×10^9 cpm. How many years will it take for the activity to fall to 3.00×10^8 cpm?
    (a) 6.13 (b) 12.26
    (c) 24.52 (d) 36.78
11. Two radioactive materials X_1 and X_2 have decay contents $10/\lambda$ and λ, respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of X_1 to that of X_2 will be λ/e after a time
    (a) $1/(10\lambda)$ (b) $1/(11\lambda)$
    (c) $11/(10\lambda)$ (d) $1/(9\lambda)$
12. One of the hazards of nuclear explosion is the generation of ^{90}Sr and its subsequent incorporation in bones. This nuclide has a half-life of 28.1 years. Suppose one microgram was absorbed by a new-born child, how much ^{90}Sr will remain in his bones after 20 years?
    (a) 0.2142 μg (b) 0.6107 μg
    (c) 0.5814 μg (d) 0.7321 μg
13. Half life of a radioactive sample is $2x$ years. What fraction of this sample will remain undecayed after x years?
    (a) $\frac{1}{2}$ (b) $\frac{1}{\sqrt{2}}$
    (c) $\frac{1}{\sqrt{3}}$ (d) 2

Multiple Correct Answers Type

14. Radioactive disintegration rate is affected by
    (a) temperature (b) pressure
    (c) electric field (d) None of these
15. The rate of decay per second of a radioactive sample:
    (a) increases proportional to the life time lived by the nucleus
    (b) decreases with the life time lived
    (c) is independent of the life lived
    (d) depends upon the total number of radioactive nuclei present in the sample
16. Which of the following relation are correct?
    (a) $\tau = \frac{1}{\lambda}$ (b) $t_{1/2} = \frac{\ln 2}{\lambda}$
    (c) $t_{1/2} = \lambda \ln 2$ (d) $\tau = \frac{\ln 2}{\lambda}$
17. It is observed that only 0.39% of the original radioactive sample remains undecayed after eight hours. Hence:
    (a) the half-life of that substance is 1 hour

(b) the mean life of the substance is $\frac{1}{\log_e 2}$ hour

(c) decay constant of the substance is $(\log_e 2)$ hour^{-1}

(d) if the number of radioactive nuclei of this substance at a given instant is 10^8, then the number left after 30 min would be $\sqrt{2} \times 10^9$.

18. Radon undergoes decay by α-emission

$$^{222}_{88}\text{Rn} \xrightarrow{t_{1/2}=3.8\text{ decay}} {}^{218}_{84}\text{Po} + {}^{4}_{2}\text{He}$$

Which of the following statements will be true for this decay process?

(a) If the initial amount of radon was 1 mg, the amount of radon left after 11.4 days will be 0.125 mg.

(b) Activity of radon after 7.6 days will be $N_0 \times (5.3 \times 10^{-7})$ s^{-1} where N_0 is the original number of atoms of the radon.

(c) The decay constant of radon is 2.1×10^{-6} s^{-1}

(d) 60% of the radon will decay in 5 days approximately

Matching Column Type

19. Match the Column I with the properties (one or more) in Column II:

Column I		Column II	
(a)	Determination of age of rock	(p)	$N = N_0\left(\frac{1}{2}\right)^y$
(b)	Carbon-dating	(q)	$\frac{0.693}{\lambda}$
(c)	Half-life	(r)	$^{238}_{92}\text{U} \rightarrow {}^{206}_{82}\text{Pb}$
(d)	β-particle	(s)	$^{14}_{6}\text{C} \rightarrow {}^{14}_{7}\text{N}$

Integer Type

20. A counter rate meter is used to measure the activity of a radioactive sample. If at certain instant, the count rate was recorded as 475 counter per minute. Five minutes later, the count rate recorded was 270 counts per minute. What is the half life period of the sample in minutes?

21. If $t_{3/4}$ and $t_{1/2}$ are time required for completion of ¾ decay and ¼ decay, then $t_{3/4} = t_{1/2} \times n$. n is ....

Comprehension Type

In the atmosphere, carbon dioxide is found in two forms, i.e., $^{12}CO_2$ and $^{14}CO_2$. Plants absorb CO_2 during photosynthesis. In presence of chlorophyll, plants synthesis glucose.

$$6CO_2 + 6H_2O \xrightarrow{h\nu} C_6H_{12}O_6 + 6O_2\uparrow$$

Half life of ^{14}C is 5760 years. The analysis of wooden artifacts for ^{14}C and ^{12}C gives useful information for determination of its age.

All living organisms, because of their constant exchanges of CO_2 with the surrounding have the same ratio of ^{14}C to ^{12}C, i.e., 1.3×10^{-12}. When an organism dies, the ^{14}C in it keeps on decaying as follows:

$$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e + \text{Energy}$$

Thus, the ratio $^{14}C/^{12}C$ decreases with the passage of time. We can measure the proportion of ^{14}C in the remains of a dead organism and determine how long ago it died. The method of carbon dating can be used to date anything made of organic matter, e.g., bone, skeleton, wood, etc. Using carbon dating, materials have been dated to about 50,000 years with accuracy.

22. ^{14}C exists in atmosphere due to:

(a) conversion of ^{12}C to ^{14}C

(b) combustion of fossil fuel

(c) bombardment of atmospheric nitrogen by cosmic ray neutrons

(d) none of the above

23. A wooden piece is 11520 yrs old. What is the fraction of ^{14}C activity left in the piece?

(a) 0.12 (b) 0.25

(c) 0.50 (d) 0.75

24. In the process of photosynthesis, O_2 gas is released from:

(a) CO_2

(b) H_2O

(c) both H_2O and CO_2

(d) mechanism is not confirmed

25. A piece of wood from an archaeological source shows a ^{14}C activity which is 60% of the activity found in fresh wood today. The age of archaeological sample will be:

(a) 4246 yrs (b) 4624 yrs

(c) 4628 yrs (d) 6248 yrs

Answers Key

Single Correct Answer Type

5. (c) **6.** (d) **7.** (b) **8.** (b) **9.** (b)
10. (d) **11.** (d) **12.** (b) **13.** (b)

Multiple Correct Answers Type

14. (a) **15.** (b, d) **16.** (a, b) **17.** (a, b, c)
18. (a, b, c, d)

Matching Column Type

19. (a → p, q, r), (b → p, q, s), (c → p, q), (d → r, s)

Integer Type

20. (6) **21.** (2)

Comprehension Type

22. (c) **23.** (b) **24.** (b) **25.** (a)

DPP 6.4

Artificial Transmutation, Nuclear Reactions, Applications of Radioactivity and Radioisotopes

Subjective Type

1. Show that the mass defect of the nuclear reaction $^{10}_{4}\text{Be} \rightarrow ^{10}_{5}\text{B} + ^{0}_{-1}e$ is given as

Δm = atomic mass of $(^{10}_{5}\text{B} - ^{10}_{4}\text{Be})$ whereas for the reaction $^{8}_{5}\text{B} \rightarrow ^{8}_{4}\text{Be} + ^{0}_{-1}e$ is given as Δm = atomic mass of $(^{8}_{4}\text{Be} \rightarrow ^{8}_{5}\text{B})$ + mass of 2 electrons.

2. Show that a mass of 1.00 u is equivalent to 932 MeV of energy.

3. Antimatter consists of particles have properties and characteristics similar to particles in known atoms but opposite charges. For example, an electron and a positron are two particles identical in every respect except for the sign of their charges. Speculate on the existence of a world composed of negative antiprotons and positrons (along with an array of other antiparticles) and neutrons. Would the chemistry in such a world have formulas similar to those of compounds on earth? What would happen if material from earth encountered material from the "antiworld"?

4. If an atom of ^{235}U, after absorption of a slow neutron, undergoes fission to form an atom of ^{139}Xe and an atom of ^{94}Sr, what other particles are produced, and how many?

Single Correct Answer Type

5. Which of the following is a spallation reaction?
   (a) $^{16}_{8}\text{O} + ^{2}_{1}\text{H} \rightarrow ^{14}_{7}\text{N} + ^{4}_{2}\text{He}$
   (b) $^{63}_{29}\text{Cu} + ^{4}_{2}\text{He} \rightarrow ^{37}_{17}\text{Cl} + 16^{1}_{0}n + 14^{1}_{1}\text{H}$
   (c) $^{2}_{1}\text{H} + ^{2}_{1}\text{H} \rightarrow ^{4}_{2}\text{He} + \gamma$
   (d) $^{238}_{92}\text{U} + ^{1}_{0}n \rightarrow ^{239}_{92}\text{U} + \gamma$

6. In nuclear reactors, cadmium is used to
   (a) slow down neutron
   (b) absorb neutron
   (c) activate neutron
   (d) absorbed energy released during nuclear reaction

7. Which represents the artificial radioactivity?
   (a) $_{13}\text{Al}^{27} + {}_{2}\text{He}^{4} \rightarrow {}_{0}n^{1} + {}_{15}\text{P}^{30} \rightarrow {}_{14}\text{Si}^{30} + {}_{+1}\text{e}^{0}$
   (b) $_{13}\text{Al}^{27} + {}_{2}\text{He}^{4} \rightarrow {}_{15}\text{P}^{31}$
   (c) $_{13}\text{Al}^{27} + {}_{0}n^{1} \rightarrow {}_{13}\text{Al}^{28}$
   (d) None of the above

8. In the nuclear reaction $^{232}_{92}\text{U} \rightarrow ^{228}_{90}\text{Th} + ^{4}_{2}\text{He}$, (Given : $m(\text{U})$ = 232.038u, $m(\text{Th})$ = 228.029u and $m(\text{He})$ = 4.003 u), the ratio of speed of α-particle and speed of light is about
   (a) 0.018
   (b) 0.036
   (c) 0.005
   (d) 0.25

9. Which one of the following nuclear transformation is (np) type?
   (a) $_{3}\text{Li}^{7} + {}_{1}\text{H}^{1} \rightarrow {}_{4}\text{Be}^{7} + {}_{0}n^{1}$
   (b) $_{33}\text{As}^{75} + {}_{2}\text{He}^{4} \rightarrow {}_{35}\text{Bi}^{78} + {}_{0}n^{1}$
   (c) $_{83}\text{Bi}^{209} + {}_{1}\text{H}^{2} \rightarrow {}_{84}\text{Po}^{210} + {}_{0}n^{1}$
   (d) $_{21}\text{Sc}^{45} + {}_{0}n^{1} \rightarrow {}_{20}\text{Ca}^{45} + {}_{1}\text{H}^{1}$

10. A nuclear reactor may be cooled by transferring heat generated from the reactor to a turbine steam boiler by using:
   (a) Fe vapour
   (b) radioactive carbon
   (c) molten sodium
   (d) compressed hydrogen

11. Liquid sodium is used in nuclear reactors. Its function is:
   (a) to collect the reaction products
   (b) to act as heat exchanger
   (c) to absorb the neutrons in order to control the chain reaction
   (d) to absorb the neutrons in order to control the chain reaction

Multiple Correct Answers Type

12. Nuclear reaction(s) accompanied by emission of neutron(s) is/are
   (a) $^{27}_{13}\text{Al} + ^{4}_{2}\text{He} \rightarrow ^{30}_{15}\text{P}$
   (b) $^{12}_{6}\text{C} + ^{1}_{1}\text{H} \rightarrow ^{13}_{7}\text{N}$
   (c) $^{30}_{15}\text{P} \rightarrow ^{30}_{14}\text{Si} + ^{0}_{1}\text{e}$
   (d) $^{241}_{96}\text{U} + ^{4}_{1}\text{He} \rightarrow ^{244}_{97}\text{Bk} + ^{0}_{1}e$

13. Which of the following statements are correct?
   (a) In the nuclear process $^{11}_{6}\text{C} \rightarrow ^{11}_{5}\text{B} + \beta^{+} + \text{X}$, X stands for antineutrino.
   (b) In the nuclear reaction, $^{3}_{1}\text{H} \rightarrow ^{3}_{2}\text{He} + e^{-} + \text{X}$, X stands for neutrino.
   (c) One atomic mass unit is equivalent to 931 MeV energy
   (d) The light radiations with discrete quantities of energ are called photons.

14. Which of the following statements are correct?
(a) The rest mass of a stable nucleus is lesser than the sum of the rest masses of its separated nucleons.
(b) The rest mass of a stable nucleus is greater than the sum of the rest masses of its separated nucleons.
(c) In nuclear fusion, energy is released by fusing two nuclei of medium mass (approximately 100 amu).
(d) In nuclear fission, energy is released by fragmentation of a very heavy nucleus.

15. Carbon-14 dating method is based on the fact that
(a) carbon-14 fraction is same in all objects
(b) carbon-14 is highly insoluble
(c) ratio of carbon-14 and carbon-12 remains constant during disintegration
(d) carbon-14 is highly soluble

16. Select the correct statement(s):
(a) ^{131}I is used for the treatment of thyroid cancer
(b) ^{59}Co cannot be used for treatment of cancer
(c) ^{33}P is used for treatment of leukemia
(d) Excessive use of radioactive elements cause cancer

Matching Column Type

17. Column I includes a few types of nuclear reactions and Column II lists some of the examples of these reactions. Identify each entry in Column I with those listed in Column II.

Column I		Column II	
(a)	Particle capture reaction	(p)	$^3_1H + ^3_1H \rightarrow ^4_2He + 2^1_0n$
(b)	Nuclear fission reaction	(q)	$^{63}_{29}Cu + ^4_2He \rightarrow ^{137}_{17}Cl + ^{16}_{10}n + ^{14}_{11}H$
(c)	Nuclear fusion reaction	(r)	$^{238}_{92}U + ^1_0n \rightarrow ^{239}_{92}U + \gamma$
(d)	Spallation reaction	(s)	$^{235}_{92}U + ^1_0n \rightarrow ^{140}_{56}Ba + ^{94}_{36}Kr + 2^1_0n$

Integer Type

18. A positron and an electron collide and annihilated to emit two gamma photons of same energy. Calculate the wavelengths in pm corresponding to this gamma emission.

19. Assuming that about 200 MeV of energy is released per fission of $^{235}_{92}U$ nuclei, then the mass of ^{235}U consumed per day in a fission reactor of power 1 megawatt will be approximately:
(a) 10^{-2} g
(b) 1 g
(c) 100 g
(d) 1000 g

Comprehension Type

Moderator is a material which is used to slow down the neutrons produced during nuclear fission. The neutrons from the source are of high speed and energy. Heavy water or graphite moderators slow down the speed of the neutrons. The energy of fast moving neutrons decreases from 2 MeV to 0.02535 eV, it corresponds to the velocity of 220 m sec^{-1}. At this velocity, the neutrons are in thermal equilibrium with the moderator. Such neutrons are called 'thermal neutrons'. Thermal neutrons cause further fission reaction. The essential characteristics of moderators are:

(i) Its molar mass must be low
(ii) It should not absorb neutrons
(iii) It should undergo elastic collisions with neutrons.

20. The moderator in a reaction:
(a) absorbs neutrons
(b) accelerates neutrons
(c) slows down neutrons
(d) absorbs thermal energy produced in the reactors

21. Which of the following is not used as a moderator?
(a) Heavy water
(b) Graphite
(c) Beryllium
(d) Sodium

22. Moderator in the reactor yields:
(a) fast moving neutrons
(b) thermal neutrons
(c) magnetic neutrons
(d) electric neutrons

23. Which among the following characters make graphite a good moderator?
(a) Cross-sectional area of graphite is very high
(b) Graphite is a good conductor of electricity
(c) There is elastic collision between graphite and neutron
(d) Graphite has weak van der Waals' force between two layers

Answers Key

Single Correct Answer Type

5. (b) **6.** (b) **7.** (a) **8.** (c) **9.** (d)
10. (c) **11.** (b)

Multiple Correct Answers Type

12. (a, d) **13.** (c, d) **14.** (a, d) **15.** (c) **16.** (a, b)

Matching Column Type

17. (a → r) (b → s) (c → p) (d → q)

Integer Type

18. (2) **19.** (b)

Comprehension Type

20. (c, d) **21.** (d) **22.** (b) **23.** (a, c)